USAID | ASIA

FROM THE AMERICAN PEOPLE

TASK 3: MONITORING INFRASTRUCTURE, EXTRACTIVE INDUSTRY AND INDUSTRIAL AGRICULTURE ACTIVITIES

FINAL REPORT

September 2015

This report was produced for review by the United States Agency for International Development (USAID). It was prepared by International Resources Group (IRG) in association with ICF International.

Cover Photo: Construction of the Song Bung 4 Hydropower Plant (ADB, 2013)

TASK 3: MONITORING INFRASTRUCTURE, EXTRACTIVE INDUSTRY AND INDUSTRIAL AGRICULTURE ACTIVITIES

FINAL REPORT

Asia Regional Environmental Field Support (AREFS)
Contract No.: EPP-I-00-06-00007
Task Order: AID-OAA-TO-11-00058

Prepared for
USAID/ASIA BUREAU
Office of Energy and Infrastructure
Urban Programs Team

September 2015

DISCLAIMER

This report is made possible by the support of the American People through the United States Agency for International Development (USAID). The contents of this report are the sole responsibility of International Resources Group (IRG) and do not necessarily reflect the views of USAID or the United States Government.

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
APRCCAA	Asia-Pacific Regional Climate Change Adaptation Assessment
AREFS	Asia Regional Environmental Field Support
CBO	community based organization
CO_2	Carbon dioxide
COP	Chief of Party
CoP	Community of Practice
COTR	Contracting Officer's Technical Representative
CSO	civil society organization
DRM	Disaster Risk Management
EGAT	Bureau for Economic Growth, Agriculture and Trade
ESP	Office of Environment and Science Policy
FAR	Federal Acquisition Regulation
FAQ	frequently asked question
GCC	Global Climate Change
GDP	Gross Domestic Product
GHG	greenhouse gas (for example, carbon dioxide or methane)
IFCCC	Intergovernmental Framework Convention on Climate Change
IPCC	Intergovernmental Panel on Climate Change
IQC	Indefinite Quantities Contract
IRG	International Resources Group
KM	Knowledge Management
km^2	square kilometer
LOE	Level of Effort
NAPA	National Adaptation Programme of Action
MDB	multilateral development bank
MDG	Millennium Development Goals
NGO	non-governmental organization
ODA	Official Development Assistance
O&M	operation and maintenance
PMP	Performance Management Plan
POC	point of contact
PPL	Bureau of Policy, Planning and Learning, USAID
PPP	public private partnerships
RFTOP	Request for Task Order Proposals
TNA	training needs assessment
USAID	United States Agency for International Development
UNFCCC	United Nations Framework Convention on Climate Change
V&A	vulnerability and adaptation

VA	vulnerability assessment

1. BACKGROUND

USAID anticipates that $ 8 trillion of infrastructure investments will be needed for the Asia Pacific region from 2011 to 2020 to meet the region's domestic and export growth requirements. However, such infrastructure and industrial agricultural and other extractive industrial development have the potential to reduce Asia's ability to adapt to climate change, particularly with regards to its impact on natural resources and fragile but critical ecosystems. For example, roads and mining concessions are reducing forested areas and associated biodiversity upon which ecosystem resilience to climate change will depend as well as meeting daily subsistence needs and supporting the basis for sustainable economic growth. It will also likely have negative impacts on the ability of the rural poor to adapt as their household incomes depend heavily on these natural resources and associated ecosystems.

The primary objective of this AREFS Task is to monitor and to document large-scale infrastructure and industrial agricultural and other extractive industrial development that can impact the environment and reduce the ability of countries and communities to adapt to climate change. The results of Task 3 will provide USAID with the information to anticipate environmental threats and impacts to development in general and specifically to USAID programs from such investments.

IRG developed a systematic approach to identifying and monitoring large scale infrastructure, extractive industry and industrial agriculture projects in the Asia Region given the limited resources available to the AREFS task order. Working with its principal subcontractor, ICF International, the IRG Team started with a broad overview of the major projects based on available online information and compared site locations with existing protected areas, areas of vital ecosystem services, global biodiversity initiatives (e.g. Global Tiger Initiative), and livelihood resources for the poor, e.g. the Mekong River Basin. From the overview and discussions with USAID staff, up to 10 critical sites were chosen for further monitoring. The IRG Team also assisted in tracking the environmental and social commitments made by project sponsors for infrastructure, extractive industry or industrial agriculture activities. Financing for these activities included loans/grants from multilateral development banks as well as loans from private financial institutions were identified to the extent possible.

1.1 SURVEYS OF INFRASTRUCTURE, EXTRACTIVE INDUSTRY AND INDUSTRIAL AGRICULTURE PROJECTS

The AREFS Project, of course, lacks anything like the funding that would be required to actually monitor all relevant activities in the Asia and the Middle East regions. Hence, our approach began with a dialogue with the AREFS COR on how to approach this task. It was agreed that we would identify those projects that met the location, size and environmental/climate impact criteria and that have sufficient information in the public realm to make description and monitoring possible.

The IRG Team identified sources of reliable information on major existing and planned infrastructure, extractive industry investments and operations and industrial agriculture activities. Sources of information included research reports, websites and databases from USAID (E3 Bureau, Asia and Middle East bureaus, and missions), international trade and investment sources, non-governmental watchdog organizations (e.g., those focused on infrastructure development, forestry, mining, agriculture), and major funding and investment organizations (e.g., World Bank, International Monetary Fund, Asian Development Bank).

Infrastructure was defined to include facilities associated with transport, water management, energy supply and industry (other than resource extraction or agriculture since they are separate foci of this subtask). For each activity identified, documentation about the location, size of the geographical area, population and potential for major environmental and economic impacts were reviewed, wherever possible.

Since no one organization provides a comprehensive source of information on all infrastructure, extractive industries, and industrial agriculture – and conducting such an examination by AREFS would be wholly infeasible from a cost and time standpoint – the Team strategically used available funding to provide a representative picture of major facilities and investments and in particular monitoring of ten very important projects.

1.2 Site Overlays and Mapping to Identify Climate Vulnerable Ecosystems and Populations

The IRG Team develop and provide USAID with an interactive map (on the AREFS website **www.climatechange-asiapac.com** and other maps in individual reports showing the location of major infrastructure, extractive industry and industrial agriculture in reference to critical ecosystems, areas of high biodiversity and the resource-dependent poor. Since the number of such installations is huge, it was necessary to make an immediate prioritization of those that the project could realistically hope to describe if not mo0nitor in real time. Infrastructure just in metropolitan areas that has some relationship to climate change would number in the many thousands.

The team will identified and described projects affecting protected areas, areas of vital ecosystem services, global biodiversity initiatives and affected populations using information from the World Database on Protected Areas (including the UN List of Protected Areas), World Resources Institute, World Wildlife Fund, the Global Tiger Initiative, and similar sources.

1.3. Prioritize specific projects for further monitoring

Based on the identification and prioritization of investment projects in 4.3.1, the IRG Team reviewed the existing analyses of the social, environmental and economic benefits, costs and impacts of these projects (existing or planned) including the impact on the climate and impact on the ability of ecosystems and communities to adapt to climate change. The Team, in consultation with the COR, selected 10 projects for in-depth description and monitoring; however, the number of projects was further reduced to six projects as four of the 10 were privately funded and information on these projects was proprietary and unavailable to the public. The objective was to monitor the projects for the life of the task order, if possible and to involve Mission personnel in those countries where the projects are located so that, at the end of the task order, they would be able to take over the monitoring or possibly help to fund a local entity (NGO or university) to continue the monitoring in the spirit of USAID Forward. The selection criteria could include characteristics such as geographic/country diversity, economic value, size of affected populations, relative income of populations, importance of the infrastructure or industry to the economy, likelihood of natural environment impacts, need for adaptation to climate change impacts, and US funding contributions to multilateral bank projects. An additional criterion of interest may be the extent to which the project is or can be influenced by USAID or another US agency.

1.4 ANALYSIS OF PROJECT RESILIENCE AND ADAPTATION TO CLIMATE CHANGE

In this sub-task, the IRG Team analyzed the degree to which the six identified projects are resilient to climate change and the extent of their impacts on critical and sensitive ecosystems and vulnerable populations. This proved to be a very labor-intensive task and so the Team had to carefully assess the impact of budgetary limitations and how they influenced the depth and breadth of analysis. It was necessary to rely mainly on available secondary source information.

This sub-task also required an analysis of the projects' fulfillment of social and environment commitments. Once the six priority projects were selected for monitoring, we tried to access the environmental mitigation and monitoring plans (EMMP) or their equivalent for each investment that defined each project's social and environmental commitments, potential environmental and climate change impacts, and mitigation measures. Using our experience as USAID's environmental compliance partner, we reviewed existing planning documents, environmental and social impact assessments, resettlement action plans, funding agreements, and other reports to identify any and all social and environmental mitigation commitments made by the developers or project sponsors.

Each of the six projects is presented in case study format and found in this report's Annex. The projects include:

1. Song Bung 4 Hydropower Plant, Vietnam
2. Xayaburi Hydropower Project, Laos
3. Tata Mundra Coal Power Plant, India
4. Dawei Seaport and Industrial Zone, Burma
5. Melamchi Water Supply Project, Nepal
6. PT Weda Bay Nickel Project, Indonesia

ANNEX – CASE STUDIES

Song Bung 4 Hydropower Plant, Vietnam


Construction of the Song Bung 4 Hydropower Plant (Source: ADB, 2013).

Table of Contents

List of Figures

List of Tables

Project Background

INTRODUCTION[1]

The Song Bung 4 Hydropower Plant project consists of a dam, a reservoir, a 156 MW hydropower plant on the Bung River, and the relocation of affected people. The Bung River (Song Bung) is a tributary of the Vu Gia River in the Vu Gia-Thu Bon basin, which is located in the Quang Nam Province in Central Vietnam (see Figure 1 for project location). The project is funded by the Asian Development Bank (ADB), Japan Fund for Poverty Reduction, and Electricity of Vietnam (EVN). It is currently under construction and scheduled to be completed by 2014.

The project aims to produce electricity to meet Vietnam's increasing energy demand and sustain economic growth in the country. Although hydropower does not release as much greenhouse gas emissions as other sources of electricity, during the first 3-5 years of operation, anaerobic decomposition of organic matter from areas inundated by the reservoir will cause a release of greenhouse gases if not mitigated. The relocation plan intends to restore and improve the livelihoods of people affected by its construction. The area displaced by the dam and reservoir is 15.65 km².

Figure 1: Project Location

TIMELINE

Phase I (2005-2008)

2005 – 2008: Identification of major environmental and social issues associated with the project.

Phase II (2008-2014)

2008: Began preliminary construction (e.g., access roads) during second half of the year.

June 2010: Started main construction.

April 2011: Began construction of resettlement sites.

November 2011 – December 2012: Relocation of affected ethnic minority people in resettlement sites.

June 2014: Expected date for the reservoir to be filled/project completion.

FUNDING

The total project cost is approximately US$254 million.

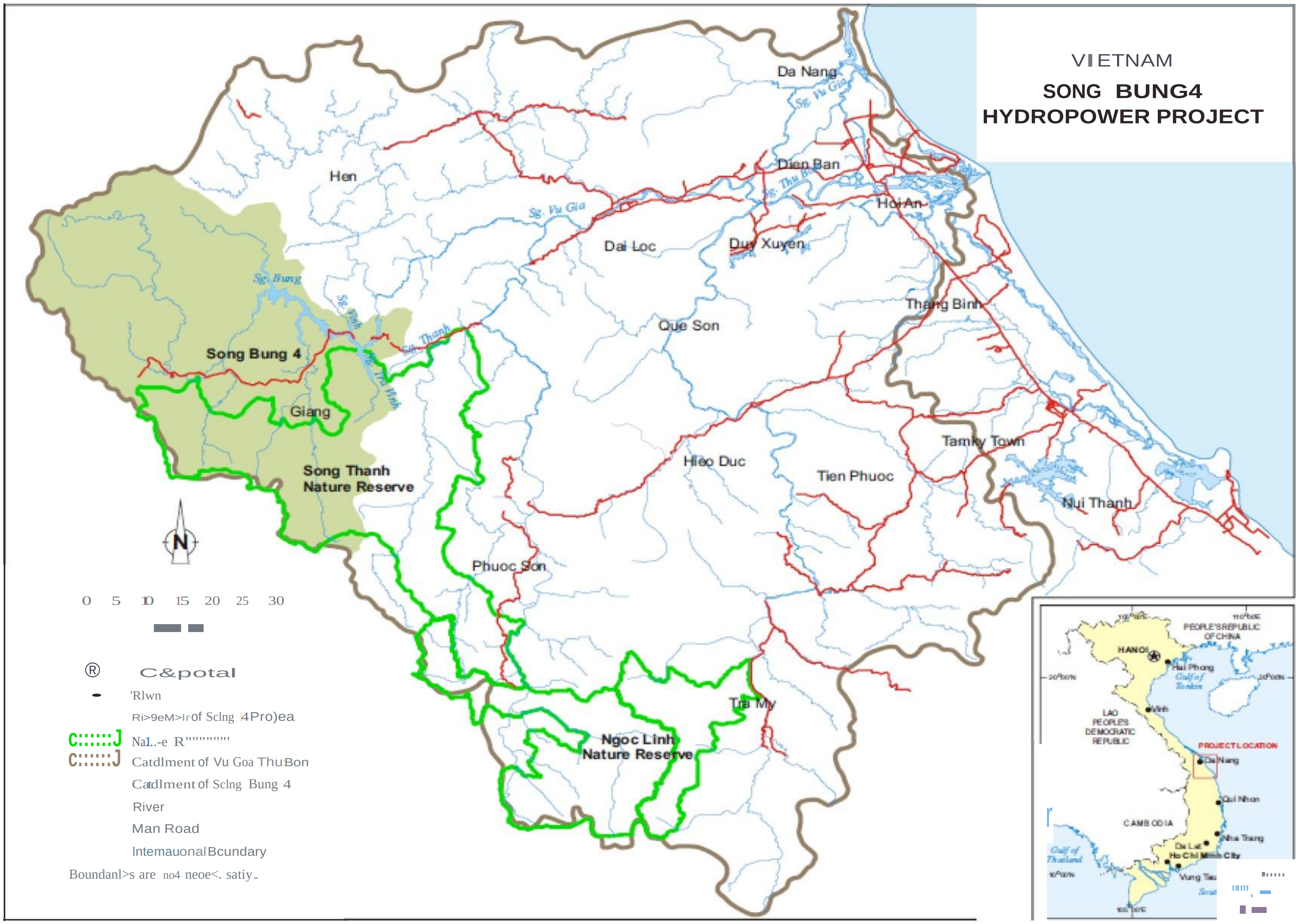
Asian Development Bank (ADB) provided a loan of $196 million, which included a US$225,000 Technical Grant for Implementation and Monitoring of the Resettlement and Ethnic Minority Development Plan (REMDP).

The Japan Fund for Poverty Reduction provided a $2 million grant for livelihood improvement of vulnerable ethnic minority communities affected by the project.

Electricity of Vietnam (EVN) is covering the remaining cost of the project, approximately $56 million.

[1] ADB, 2012.

Figure 2: location of Song Bung Hydropower Project[2]



---

[2] Government of Vietnam, 2006.

PROJECT LOCATION

Location of the hydropower plant

The Song Bung dam and production facility is located on the Bung River, about 3 km upstream of the confluence with the A Vuong River. The Vu Gia-Thu Bon basin is located in the Quang Nam Province in Central Vietnam (see. Figure 2 for project location). This area is predominantly inhabited by indigenous people who belong to the Co Tu ethnic minority and the project is expected to result in displacement of more than 1,200 Co Tu people.

Another hydropower plant located near the Song Bung project is Song Tranh 2. Song Bung and Song Tranh 2 are two of eight large hydropower plants in the Vu Gia-Thu Bon basin. Song Tranh 2 started construction in 2006 and was completed around 2011. Since the completion of the Song Tranh 2 dam, the region has been identified as having geological faults and several earthquakes occurred in the project area in 2012. Strong earthquakes will cause danger for both the plant and people in the downstream area.[3] Estimates predict that 31,000 people would be affected by flooding if the Song Tranh 2 dam were to break.[4] The Vietnamese government is reported to have hired OYO Corporation, the largest geo-engineering consulting firm in Japan, to assess the earthquake in the Song Tranh 2 hydropower plant area. The research will help Vietnamese management agencies determine whether the power plant's water storage is the cause of the earthquakes and whether it is safe to fill the reservoir.[5]

According to Song Bung's Environmental Impact Assessment (2007), the dam and production facility are located on geologic foundation that has competent sandstone and siltstone that is favorable for the construction of a hydropower project. [6] However, there has not been additional study on the geology of Song Bung 4 area since the occurrence of earthquakes at Song Tranh 2 hydropower plant.

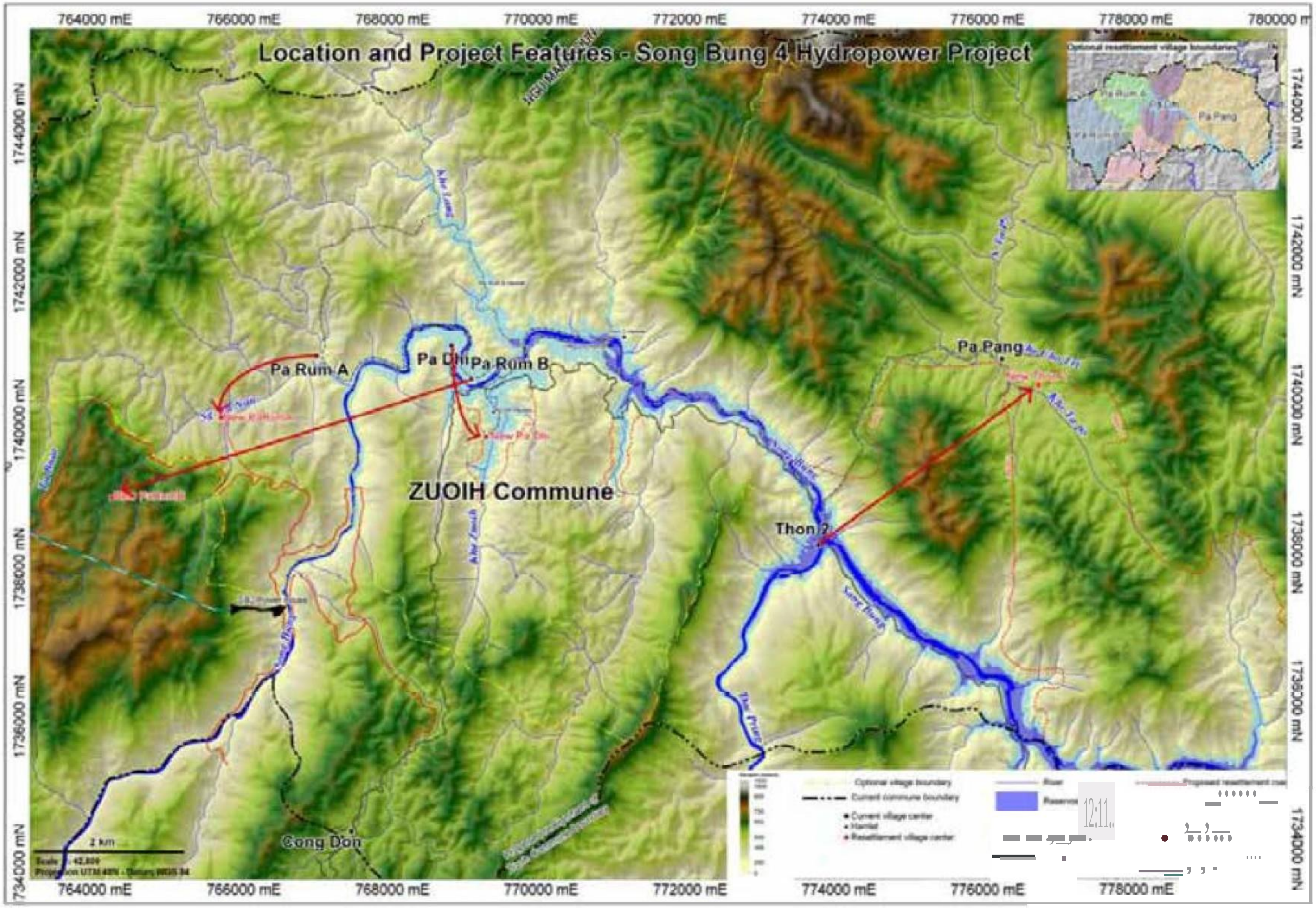
The southern part of the project's catchment area is within the Song Thanh Nature Reserve, which is the largest Vietnamese protected area in the Greater Annamites Ecoregion and is part of the Greater Mekong Biological Conservation Corridor Initiative. The Reserve consists of large tracts of intact forest, and is home to highly threatened and endangered species such as tigers, bears, hornbills, gibbons, and Asian elephants.[7]

Relocation sites (see Figure 3)[8]

Four villages in the area – Thon 2, Pa Rum A, Pa Rum B, and Padhi – will be directly affected by the construction of the reservoir. Thon 2 will be relocated to Pa Pang, an inhabited mountain village that is remote and not easily accessible. Pa Rum A will move 1.5 km away from their existing village. Pa Rum B will move 6 km away from their existing village. Padhi will move to higher ground from their existing village.

[3] VietNamNet Bridge, 2012.
[4] Huy Hoang, 2012.
[5] Lan Huong, 2013.
[6] SWECO International, 2007a.
[7] WWF, 2012.
[8] SWECO International, 2010.

Figure 3: location of Resettlement Sites[9]



---
9 SWECO International, 2010.

PROJECT ASSETS AND OPERATIONS

The primary objective of the Song Bung 4 Hydropower Project is to produce electricity to meet Vietnam's growing energy needs. While not designed as a multipurpose dam, the project stated that the reservoir could potentially be used to increase water supply for irrigation in dry periods and mitigate floods in the river system. If part of the reservoir is used for irrigation and flood control, the irrigation benefit of the Song Bung 4 Project is estimated at US$ 0.2 million per year and the flood control benefit at US$ 0.3 million per year. The net present value of net benefits from electricity generated by Song Bung 4 over the project's economic lifetime (40 years) is estimated to be US$ 51.06 million.[10] The assets and operations of the project are as follows.

Project Assets

The dam will be 110 meters (m) high and will create a reservoir with an area of 15.65 km² at Full Supply Level. The reservoir regulation, or the difference between the Full Supply Level and Minimum Operation Level, will be 27.5 m. The design head is 104.9 m and the project has a mean annual energy potential of 537 million kWh. A spillway with five radial gates will be incorporated into the dam structure, and is designed for a 5,000-year flood of about 15,500 m^3/s.[11] Floods will be attenuated when passed through the reservoir giving an outflow from the spillway of some 10,798 m^3/s at a 5,000-year flood. An acoustic warning system is recommended to be installed from the dam down to the confluence with Cai River to warn people when the spillway gates will be opened.

Structures to divert the water from the reservoir to the power station, including (i) a freestanding 50 m high intake structure about 400 m south of the dam to convey the water to the headrace tunnel, (ii) a 75 m high surge tank, and an underground penstock 270 m in length and 5.2 m in diameter at the downstream end of the headrace tunnel, and (iii) a 20 m long tailrace canal to divert the water back to Bung River.

A power station with the necessary facilities to generate electricity will be constructed. The powerhouse will be a 68 m high, 58 m long, and 24 m wide surface structure located close to the river. Five hundred meters downstream of the powerhouse, there will be a switchyard measuring 70 m by 143 m. The buildings will be placed at an elevation of 125 m, being 0.5 m above the level for a 5,000-year flood.

A 34 km long 220 kV transmission line will connect the power station with the national grid.

Road networks will connect the project site and resettlement areas to the national road system. Auxiliary areas will undergo development to enable construction and operation of the project. This will include relocating a 2,867 m long stretch of Highway 14D and constructing a 326.45 m long, 75 m high temporary bridge over Tru Vinh (a tributary to Bung River). Permanent access across the river will be on the crest of the dam, once it is completed.

Among these, the three key features are the dam, the underground water conveyance system, and the power station. Water from the Song Bung 4 Reservoir will be diverted, via a headrace tunnel and an underground penstock, to a power station located on Bung River about 5 km downstream of the dam. The difference in elevation between the reservoir and the power station is about 125 m at Full Supply Level. From the power station the water is conveyed back to Bung River via a short tailrace canal. The general layout of Song Bung 4 Hydropower Project is illustrated in Figure 4.

Project Operation

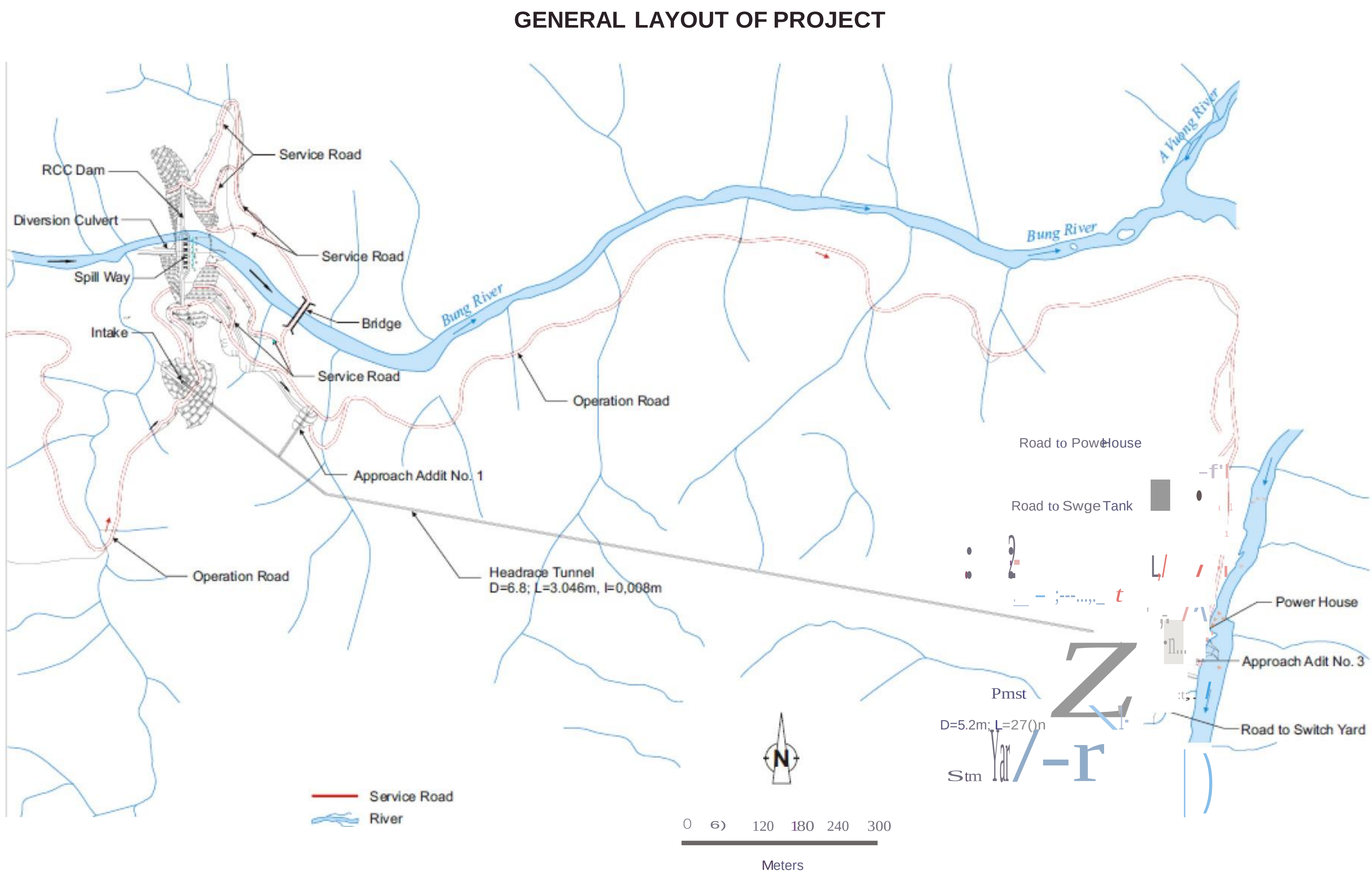
The reservoir will be operated for seasonal regulation of the inflow. It is anticipated that the reservoir will be filled-up to the Full Supply Level during the wet season, from September to December, and be drawn down to the Minimum Operating Level by the end of the dry season, in August. The future operation pattern of Song

[10] SWECO International, 2007b.

[11] Observed annual floods at the gauging station Thanh My in Song Cai (Cai River) were used as basis for the calculations of the 5,000-year flood (SWECO International, 2007a).

Bung 4 power station may vary according to demand and available supply. Currently, the plant is scheduled to operate from 6 am to 10 pm and stop for the rest of the day.

Figure 4: General layout of Song Bung 4 Project Components[12]



[12] Government of Vietnam, 2006.

Environmental and Social Impacts

Environmental Benefits

The Song Bung Hydropower Plant IV is one of several hydropower plants that are part of Vietnam's plan to expand the domestic energy supply. Anticipated environmental benefits of the project may include: fewer greenhouse gas emissions compared to fossil fuel energy; flood control improvements on Vu Gia River; increased irrigation during the dry season; reduction of salt intrusion on the floodplain; and additional opportunities for aquaculture in the reservoirs and in the rivers. The reservoir is estimated to have a natural fish productivity of 20 kg/ha per year, and aquaculture could increase fish productivity by an additional 5 kg/ha. However, reservoir fisheries will likely not be able to fully replace the loss of riverine fisheries.[13]

Environmental Concerns

The project will have some significant localized environmental impacts, including a shift in the river flow, impacts on aquatic ecology, and increased pressure on the Song Thanh Nature Reserve. Dam building is considered the most substantial impact on riverine ecosystems. Habitat fragmentation, isolation, and the development of infrastructure can have significant impacts on species survival.[14] The specific environmental impacts of the Song Bung Project include:

Irregular river flow: The project will reduce the flow on a 5.5 km stretch of the Bung River between the dam site and the outlet from the power plant, and will affect the flow further downstream. Due to the dam operations as described above (operating from 6 am to 10 pm and stop for the rest of the day), if there is no release of compensation flow from the dam, the flow during the drier part of the year will normally be almost equal to zero on the first 3.5 km downstream of the dam (at which point Song Bung has its confluence with A Vuong River).[15]

Reduced flooding: The Song Bung 4 reservoir will reduce the flood flow downstream of the power plants during a "normal" flood situation. However, during very large floods, such flood control effects will hardly be noticeable.[16]

Downstream aquatic ecology: The project will have a significant negative impact on the aquatic life downstream. Long-distance migratory species (e.g., the highly priced fish *Angulla marmorata,* which migrates from the river to the ocean to reproduce) will likely disappear due to the barrier effect of the dam that will disrupt migration.[17] The large diurnal flow and water level variation in the river between the dam and the confluence with Cai River will strongly reduce the biological productivity of the river, by up to 75%. Periphyton, bottom animals, and fish will decline, both in production and in biodiversity. In the stretch downstream of the confluence with Cai River, the impacts will be smaller—but are still estimated to be up to 30% loss in fish yield.[18]

Upstream aquatic ecology: In the areas upstream of the dam, the inundation will result in a loss of river habitat of 30 km, which will be replaced by a lake with large water level fluctuation (planned 27.5 m between Full Supply Level and Minimum Operating Level). In the first years after the regulation, fish productivity will be relatively good because of the supply of food and nutrients from the inundated terrestrial land. However, over time, fish productivity is likely to be markedly reduced and the potential for fish harvest will be low. Only a few fish species will succeed in adapting to a lake life. In the reservoir, the biodiversity of fish will be reduced by 30-

[13] SWECO International, 2007a; Government of Vietnam. 2006.
[14] Grumbine and Maharaj, 2013.
[15] SWECO International, 2007a; Government of Vietnam. 2006.
[16] SWECO International, 2007a.
[17] SWECO International, 2007a.
[18] SWECO International, 2007a; Government of Vietnam. 2006.

50%. However, most of these species will survive in small populations in the upstream part of the river and in the tributaries. [19]

Terrestrial ecosystems: The reservoir will flood 142.65 ha of the Song Thanh Nature Reserve, or less than 0.2% of the total reserve area. The inundated area has been subject to logging and is used for non-timber forest product collection and illegal hunting.[20] Increased access to the reserve through the reservoir and the realigned highway 14D can cause more illegal logging, hunting, and non-timber forest product harvest. This could result in potential loss in terrestrial biodiversity and habitats and increase in landscape fragmentation.

In addition, to reduce greenhouse gas release from anaerobic decomposition of organic matter in the inundated areas, the Environmental Impact Assessment recommended the clearance of forest, trees, and bushes in the reservoir area prior to filling the dam. However, it is unclear whether this was implemented, and if yes whether the forest products and non-timber forest products from the cleared area were harvested and sold.[21]

Social Impacts[22]

Relocation: The Song Bung 4 reservoir impact zone includes three villages that will be completely flooded and one village that will be partially flooded. In the four affected villages in the reservoir area, the project will flood houses and housing land, agricultural land (wet paddy rice upland fields, some fruit tree gardens, some of the rotational fields), most of the fish ponds, 50% of the grazing ground, and 10-15% of the forest resources along the Bung River. The project will also inundate community and cultural infrastructure, including Co Tu meeting halls, schools, a health center, communal recreation lands, and graves and other spiritual sites. The project developer stated that all of these community assets will be fully restored as part of the Resettlement and Ethnic Minority Development Plan (REMDP).

In addition, the project will seriously impact the riverine fisheries in Song Bung and its major tributaries of three villages (Thon 2, Pa Dhi, and Pa Rum B), and part of the fourth (Pa Rum A). The estimated loss of total annual catch is 49,000 kg, or an average of 243 kg per household. The loss of riverine fisheries and cattle grazing land based livelihoods will have significant socio-cultural impacts on the relocated villages. There can be possible social stress and loss of social resilience as a result of the resettlement.

- Three villages, Thon 2, Pa Rum B, and Pa Dhi, will be completely flooded and will require relocation and full livelihood restoration.
- One village, Pa Rum A, will be partially flooded permanently and most of the village will be seasonally flooded during the rainy season. The entire village must be relocated since there is a lack of suitable land to move the permanently inundated portion of Pa Rum A within their existing village.A fifth village, Pa Pang, will be affected as the host village for Thon 2 resettlers. Pa Pang currently has 25 households, who are also of Co Tu ethnicity as the majority of Thon 2 residents. Although Pa Pang will not be directly impacted by the construction of the dam, land acquisition for the resettlement of Thon 2 can negatively affect Pa Pang residents. On the other hand, Pa Pang can benefit from the project resettlement activities. Pa Pang currently has limited community infrastructure, and as part of the resettlement program, the village will receive payment for a new internal road, domestic water supply, and electricity, as well as a new communal house, commune administrative center, health center, kindergarten, primary and secondary school that will be shared between Pa Pang host village and Thon 2 resettlers.
- In addition, four households from Vinh village of Ta Bhing Commune will be inundated and relocated.

[19] SWECO International, 2007a.
[20] Government of Vietnam, 2006.
[21] SWECO International, 2007a.
[22] SWECO International, 2010.

Other concerns with the resettlement sites include:

- Relocation of Thon 2 to Pa Pang, a mountain village that is remote and not easily accessible. If no measure is taken, Thon 2 residents will not be able to continue their fishing activities. The project stated that it would build an access road from Pa Pang to the reservoir to address this problem.
- Relocation of Pa Rum B 6 km away from their existing village will limit access to their existing upland fields and fishing on the Bung River.
- According to the NGO Forum on ADB and Vietnam Rivers Network, two civil society groups in the area, interviews with local residents reveal concerns about the relocation plan: Residents expressed worries that the resettlement sites are not as flat, and are less fertile for agricultural cultivation and raising livestock than their historical homes. They stated that there is not enough land to practice their traditional crop rotation, and that the resettlement sites are farther from the river, which may result in limited water resources and make it difficult to continue fishing activities. In addition, residents were concerned that roads to the fields and forests are long and steep, making them susceptible to damage during the rainy season.[23,24]

Project construction and auxiliary lands impact zone: Local villagers are impacted by land acquisition for the infrastructure construction. A total of 431 households are affected by the construction activities, 42 of which are severely affected (defined as those losing 10% or more of their productive assets). Of the 42 severely affected households, 41 are located in Ton Vinh village. In addition to the households affected by construction activities, the reservoir inundation will affect part of the upland of 31 households in Ton Vinh village, and the 220kV transmission line will displace an additional number of households (the exact number of affected households was not specified).

Downstream and upstream areas of Song Bung 4 Reservoir: The project will have negative impact on riverine fisheries downstream and upstream of the dam (see "Environmental Concerns" above for more information). The affected downstream and upstream areas can be divided into four main zones in terms of social and livelihoods impacts:

- Downstream Zone 1, which is between Song Bung 4 dam site and close to the confluence with Cai River. Pa Dau 2 is the only village in this area and is located 1 to 2 km from the river. All households are Co Tu ethnic minority. The Song Bung Hydropower project is expected to result in fisheries loss of about 4,200 kg/year. In addition, water level fluctuations can affect about 12 hectares of cultivation land near the river.
- Downstream Zone 2, which is around the confluence of Bung River and Cai River, after which the river is called Vu Gia River. Eight villages are located in this area, all of which belong to Kinh ethnic group (the ethnic majority in Vietnam). Of the total 679 households in these villages, 98 are involved in fishing activities.
- Downstream Zone 3, which is further downstream from the confluence of Bung River and Cai River up until the Quang Hue River, a short channel connecting Vu Gia River to Thu Bon River. Ten villages are located in this area, all of which are of Kinh ethnic group. 1,678 out of a total of 10,868 households fish in Vu Gia River.
- Upstream Zone, which includes all villages in the watershed of Song Bung reservoir residing on and/or catching fish from streams above the Song Bung reservoir. A total of 32 villages reside in this area.

There will be impacts on the fish catch as well as non-fisheries livelihoods in downstream zone 2, downstream zone 3, and upstream zone. However, it is not possible to estimate the magnitude of these impacts as there is no proper understanding of the future impacts on fisheries in these areas. The project's REMDP stated that it

[23] Lam Dinh Uy, Undated.
[24] Vietnam River Network, 2012.

would conduct a one-year baseline study, followed by monitoring of fisheries from the commencement of the project operation (expected to be in 2014) for a minimum of five years, to estimate the scale of impact and determine appropriate compensation. A separate volume of the REMDP will be prepared to assess the project impacts on these downstream and upstream areas and develop a mitigation and resettlement plan. This volume has not been published on ADB website as of April 2013.

Influx of workers: The project may cause construction related social impacts due to the large influx of Chinese workers and Vietnamese Kinh workers and camp followers. The number of workers and construction camp followers are expected to be from 2,500 to 3,000 people. Construction work camps will affect Thon Vinh and Pa Toi villages (with a total of 117 households, almost all of which are of Co Tu ethnicity).[25] The construction related impacts may include social conflict, social and possibly moral disruption, possible increase in transmitted diseases, possibly increase in human trafficking, increase on prices of food products due to increased demand for local foods, and extraction of natural resources by the immigrants.[26]

ENVIRONMENTAL AND SOCIAL COMMITMENTS

Electricity of Vietnam, the owner of the project, specified in its loan and project agreement with the ADB that it would implement the **Resettlement and Ethnic Minority Development Plan (REMDP)** in a timely and effective manner. The REMDP includes the provision of new resettlement sites, including associated infrastructure such as access roads, and improvement of common facilities such as schools and health facilities; and assistance to restore and improve the livelihoods of the affected people. The REMDP has separate volumes specifically designed for each impacted area (reservoir impacted area, project construction lands and transmission line impacted area, and downstream and upstream impacted area). EVN also promised to properly inform and effectively engage the affected people in the design and implementation of the project and the REMDP, and to establish and ensure grievance redress mechanisms.[27]

EVN promised to prepare and implement a **Gender Action Plan** to integrate gender issues into the project. This includes commitments such as ensuring land use rights for farming and user rights for forest products to be issued in the names of both husband and wife; inclusion of women in trainings; and organization of separate workshops for the Co Tu women for design and implementation of livelihood activities under the REMDP. EVN is required by the ADB to develop monitoring indicators disaggregated by gender and ethnic groups, and conduct gender sensitization training for the staff of the resettlement committees.[28]

EVN also prepared a **Social Management Plan**, which includes a Public Health Action Plan and a Construction Phase Social Management Plan to ensure the health and safety of the local population affected during the construction and operation phase of the project. One of the objectives of the Social Management Plan is to address the possible impacts caused by the influx of immigrant workers.[29]

EVN is committed to mitigating the environmental impacts of the project through an Environmental Management Plan, which includes the implementation of the mitigation and conservation offset plans, environmental protection and capacity building plan, and monitoring of the implementation. The conservation off-set plan includes a community-based forest management program that aims to reduce illegal logging and enhance forest quality and soil conservation of the watershed. Details of the Environmental Management Plan are available in the Environmental Impact Assessment report.[30]

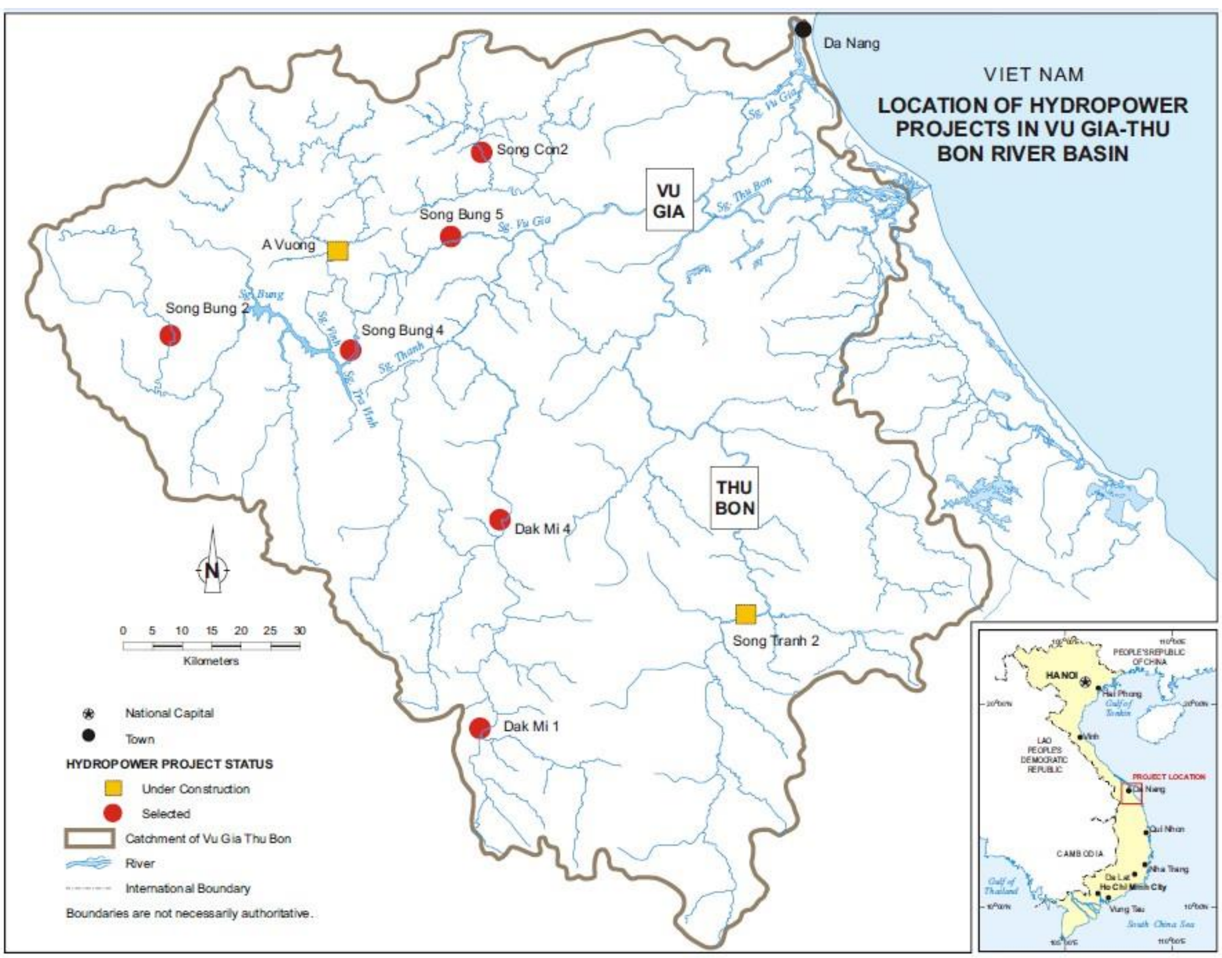
[25] SWECO International, 2007c.
[26] SWECO International, 2007a.
[27] ADB, 2008a.
[28] ADB, 2008a.
[29] SWECO International, 2007c.
[30] SWECO International, 2007a.

CUMULATIVE IMPACTS

Song Bung 4 is one of the eight large hydropower plants in the Vu Gia-Thu Bon river system, most of which have been completed or are near completion as of December, 2012 (see Figure 5 for locations of hydropower plants in the river basin and Table 1 for some project details). According to the Song Bung Environmental Impacts Assessment (SWECO International, 2007a), the possible positive impacts of these eight hydropower plants are reduced greenhouse gas emissions compared to energy from fossil fuels; increased flow in dry periods; improved flood control; reduction of salt intrusion on the floodplain; and addition to natural fish production in the reservoirs and fish production in the rivers because of aquaculture in the reservoirs. However, in addition to the benefits listed in SWECO, the plants can cause:

- build-up of sediment in reservoirs;
- increased water loss through evaporation from reservoirs;
- erosion in reservoirs and downstream river stretches because of water level fluctuations;
- riparian vegetation and habitat destruction along the banks of reservoirs and rivers;
- reduction in fish populations and diversity in reservoirs and affected rivers;
- significant reduction in fish migration;
- negative consequences for estuarine and coastal fisheries; and
- loss in terrestrial biodiversity and habitats, and increase in landscape fragmentation.

Figure 5: Location of 8 Large Hydropower Projects in Vu Gia - Thu Bon River Basin[31]



---

[31] Government of Vietnam, 2006.

Table 1: Hydropower plants in Vu Gia – Thu Bon basin

Project Name	Capacity (MW)	Reservoir Regulation (m)	Active Reservoir Capacity (mg/m^3)	Construction Status
A Vuong	210	40.0	266.5	Completed
Dak Mi 1	215	35.0	93.4	Under construction
Dak Mi 4	180	18.0	158.0	Completed
Song Bung 2	100	40.0	69.2	Under construction
Song Bung 4	**156**	**27.5**	**320.7**	**Under construction**
Song Bung 5	85	2.0	4.6	Completed
Song Con 2	46	1.0	0.1	Completed
Song Tranh 2	162	35.0	521.1	Completed
Total	**1,154**			

In addition to the eight large projects, there are a significant number of existing and planned medium and small hydropower projects in the basin. As of 2008, the number of proposed hydropower projects in the basin amounted to over sixty.[32]

In 2005, ADB approved a grant for Strategic Environmental Assessment of hydropower plants in the Vu Gia-Thu Bon basin. The final report, published in 2008, concludes that "the pace and scale of proposed hydropower development is at a level which cannot be sustained. As it stands, the plan with all its additional projects will be detrimental to the economies of the two provinces concerned (Quang Nam and Da Nang), and will have serious negative consequences for the natural systems in the basin and for the livelihoods and wellbeing of the ethnic minority groups most affected".[33]

In October 2012, the People's Committee of Quang Nam Province decided to cancel 23 small and medium hydropower projects in the province due to their potential impacts on the population, production lands, and environment, among other reasons.[34] [35] However, the eight large projects (listed in Table 1) were either completed or already under construction.

ADHERENCE TO COMMITMENTS

The ADB required EVN to hire independent consultants to monitor the implementation of the REMDP, Environmental Management Plan, and Gender Action Plan.

Social Consult was hired as independent monitors and is required to submit detailed reports of the Environmental Management Plan to EVN and ADB every six months during construction, and annually for two years after completion of construction.[36] As of February 2013, only one Environmental Monitoring Report had been released. The semestral report covers the period from July to December 2012. A snapshot of the potential environmental impacts and the level of compliance are available in Table 2. For more specific information about

[32] ICEM, 2008.
[33] ICEM, 2008. The study also recommends seven principles and thirty four mitigation and enhancement measures that the hydropower developments should follow to enhance the sustainability and equity of the hydro sector in the basin.
[34] Vietnamnet, 2012.
[35] Talk Vietnam, 2012.
[36] SWECO International, 2007a.

the proposed mitigation measures and specific implemented activities, see the *July-December 2012 Environmental Monitoring Report*.[37]

Table 2: Potential Environmental Impacts and Compliance[38]

Potential environmental impacts	***Compliance***
Dust, noise and air quality reduction	Partly complied
Wastes from domestic use, construction wastes, hazardous wastes	Partly complied
Construction wastewater, domestic water waste	Partly complied
Reduction of Bung water quality, water courses nearby	Partly complied
Safety on site	Complied
Impact on soil environment and vegetation	Not available
Biological impacts	Complied

Although the previous semi-annual report for 2012 is not currently available online, it is reported that the contractor retained approximately $2 billion VND for the repeated non-conformance of several activities, including: dust, poor sanitary hygiene at workers' camps, truck overloading, and erosion at disposal area No. 02.[39]

The independent monitors shall also submit reports of the REMDP and Gender Action Plan every six months during project implementation until the objectives of the REMDP has been achieved.[40] Information regarding the consultant's monitoring efforts and EVN's adherence to its commitments for this project are not available online as of February 2013.

Background on Climate Change and Hydropower Projects

Hydropower is widely accepted as a good alternative to fossil fuels that can provide clean energy to growing economies. Currently, hydropower meets approximately 20% of the global energy demand and the output is anticipated to increase three-fold by 2100.[41] A number of studies have explored the impact of climate change on hydropower projects. The extent of the research is largely limited to assessing the economic output under changing hydrological conditions and global markets.

A World Bank commissioned study of the impacts of climate change on hydropower projects in India, Sri Lanka, and Vietnam focused on three main impacts of climate change on hydropower:[42]

(1) **Temperature and precipitation shifts** may alter the discharge of a river and impact the amount of energy produced by the project. Hydrological periodicities and seasonality changes can affect the operations (such as peak versus base load) of the hydropower plant.

(2) An expected increase in climate variability may trigger more extreme events, including **floods and droughts,** which could impact the energy production capacity.

[37] Song Bung 4 Hydropower Project Management Board, 2012.
[38] Song Bung 4 Hydropower Project Management Board, 2012.
[39] Song Bung 4 Hydropower Project Management Board, 2012.
[40] ADB, 2008a.
[41] Harrison et al., 2006.
[42] World Bank, 2007.

(3) Changing hydrology and extreme events may change **sediment risks** which could increase exposure to turbine erosion. In addition to major, destructive events, smaller changes could lower turbine and generator efficiency, resulting in output declines.

The studies largely focus on the changes in precipitation and temperature. Changes in precipitation are positively correlated with runoff – an increase in precipitation results in higher runoff. Changes in temperature are negatively correlated with runoff – higher temperature increases evaporation and results in lower runoff (assuming no change in precipitation).[43] Shifts in precipitation have a more direct impact on runoff, than changes in temperature. The Harrison et al. 2006 study of the proposed 1600 MW Botoka Gorge project for the Zambezi River on the Zambia-Zimbabwe border estimated that a 20% increase in rainfall resulted in a 46% increase in runoff. Comparatively, a 1°C increase in temperature caused a 2% decrease in runoff. Additionally, the study found that the changes in runoff were more dramatic during high flows (due to the inability of wet soils to absorb more water), than during low flows.[44] While these numbers are specific to the Zambezi River project and cannot be applied to Song Bung or other hydropower projects, the direction and amplitude is illustrative:

- An increase in precipitation will likely cause a notable increase in runoff;
- An increase in temperature will likely cause a modest decrease in runoff; and
- Changes in runoff will likely be more significant during high flows than during low flows.

The impact of shifts in river discharge varies between generating methods – for example, a run-of-the-river station without storage capacity would be more sensitive to seasonal changes and hydrological periodicities than a conventional plant with a dam and reservoir (like the Song Bung project). Storage capacity will help reduce the impact changes in the timing and intensity of precipitation events.

In addition to shifts in river flows, extreme events may impact the viability of a project. Extreme events may cause direct damage to the facilities, which could result in costly repairs or facility destruction. Changes in sediment could also have cumulative impacts on the efficiency and operation of the facilities. While not an immediate threat in Central Vietnam, wildfires can result in increased erosion and sediment risk to the facility. In summary, the four climate change factors that are likely to directly impact the operation of a hydropower plant are: changes in precipitation, temperature, extreme events, and wildfires.

Local Conditions

CURRENT LOCAL CLIMATE

Vietnam has a monsoon tropical climate with annual mean temperatures that range from 12.8°C to 27.7°C and average annual rainfall that ranges from 1,400 to 2,400 mm. At every location measured for the past nine decades (1911-2000), there has not been a distinct or consistent change in annual rainfall. Across the country there have been periods when rainfall has increased and periods when rainfall has increased.[45] The country is affected by an average of six to eight typhoons or tropical cyclones a year.[46]

The annual average temperature has increased about 0.5 to 0.7°C during the last fifty years (1958 – 2007). Winter temperatures have increased faster than summer temperatures and those in the Northern climate zones

[43] Harrison et al., 2006.
[44] Harrison et al., 2006.
[45] MoNRE, 2009.
[46] Government of Vietnam, 2010.

faster than those of the Southern climate zones.[47] During the period 1991-2000, annual average temperatures in Da Nang were 0.4°C higher than the average temperatures between 1931 and 1940.[48]

With changes in temperature and rainfall, evapotranspiration will likely increase in the South Central Coast and annual river flows are bound to change – with increases in June through November and decreases in December through May. The wet season in Quang Nam province is September through December, there is a mild dry season from January to March, and a dry season April through August. The Song Bung 4 project is planning for the lowest river flows to occur in August, at the end of the dry season. Although groundwater is heavily used in other regions of the country, the supply is limited in Quang Nam and Da Nang provinces (the location of the Song Bung project) and thus surface water is the primary source of water for the region.

CLIMATE CHANGE PROJECTIONS

Precipitation

Precipitation projections tend to be less accurate than temperature projections. The Ministry of Natural Resources and Environment produced climate change and sea level rise scenarios for seven regions of Vietnam.

As shown in Table 3, under all emissions scenarios, precipitation is anticipated to decrease December through May and increase June through November. It should be noted that the three-month groupings used in the Ministry of Natural Resources and Environment 2009 report do not strictly follow the wet (Sept-Dec), mild dry (Jan-Mar), and dry (Apr-Aug) seasons in the Quang Nam province and thus more extreme increases or decreases may be obscured by the data aggregation. Under the medium emission scenario (B2), the South Central Vietnam climate zone is projected to experience up to a 4.1% decrease during the dry season and a 3.5% increase during the wet season by 2030.[49] By the end of the century the dry season decrease is projected to be 14.2% with an increase during the wet season by as much as 12.1%.[50]

The 2012 Climate Change, Sea Level Rise Scenarios for Vietnam that was prepared by the Ministry of Natural Resource and Environment suggests modest annual rainfall increases. Under the medium emission scenario (B2) annual average precipitation projections for the Quang Nam province are about 1% increase by 2030 and 2-5% increase by the end of the century.[51] In the next 100 years, it is projected that the maximum values of daily rainfall will decrease in the South-Central region.[52]

[47] MoNRE, 2009.
[48] MoNRE, 2009.
[49] MoNRE, 2009.
[50] MoNRE, 2009.
[51] MoNRE, 2012.
[52] MoNRE, 2012.

Table 3: Rainfall change (%) in South Central Vietnam climate zone relative to the period of 1980-1999[53]

Emissions Scenario	Month Periods	Decades in 21st Century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
low emission scenario (B1)	Dec-Feb	-2.0	-2.9	-4.2	-5.1	-5.8	-3.5	-4.8	-6.7	-6.7
	Mar-May	-2.8	-4.1	-5.7	-7.1	-8.2	-8.7	-9.1	-9.3	-9.3
	Jun-Aug	0.8	1.1	1.6	1.9	2.2	2.4	2.5	2.6	2.6
	Sep-Nov	2.4	3.5	4.9	6.0	6.8	7.8	7.7	7.9	7.9
medium emission scenario (B2)	Dec-Feb	-2.0	-2.9	-4.2	-5.4	6.5	-7.6	-8.6	-9.5	-10.2
	Mar-May	-2.8	-4.1	-5.7	-7.4	-9.0	-10.5	-11.9	-13.1	-14.2
	Jun-Aug	0.8	1.1	1.6	2.1	2.5	2.9	3.3	3.6	3.9
	Sep-Nov	2.4	3.5	4.9	6.3	7.6	9.0	10.1	11.1	12.1
high emission scenario (A2)	Dec-Feb	-2.2	-3.0	-4.0	-5.3	-6.3	-8.0	-9.6	-10.5	-13.0
	Mar-May	-3.0	-4.2	-5.5	-7.1	-8.9	-11.0	-13.2	-15.6	-18.1
	Jun-Aug	0.8	1.2	1.5	1.9	2.5	3.1	3.7	4.3	5.0
	Sep-Nov	2.5	3.5	4.6	6.1	7.6	9.3	11.3	13.3	15.3

Key	Change of less than |5|%	Change of |5| to |10|%	Change of more than |10|%

Runoff

A combination of 56 climate change scenarios show that the national dry season mean runoff will generally be reduced and the wet season peak runoff will be increased.[54] These 56 scenarios also show increased precipitation and increased runoff in the Central region.[55] These findings are consistent with the UNFCCC 2nd National Communication, which projected a rise in flood flows of less than 2% for 2040-2059 and less than 3% for 2080-2099 for the Thu Bon River (under the medium scenario B2).[56] The Vu Gia – Thu Bon basin is projected to experience more intense rainfall, more variability, and increase in size of extreme flood flows.[57]

Average Temperature As shown in Table 4, under all emissions scenarios, the temperature in the South Central climate zone is projected to increase. Under each of the emissions scenarios, by 2050, a 1°C increase is projected for the majority of the year. Under the high emissions scenario, between June and August, the increase is projected to reach 2.8°C by the end of the century.

[53] MoNRE, 2009.
[54] Gebretsadik et al., 2012.
[55] Gebretsadik et al., 2012.
[56] Government of Vietnam, 2010.
[57] ICEM, 2008

Table 4: Mean temperature change (°C) in South Central Vietnam climate zone relative to the period of 1980-1999[58]

Emissions Scenario	Month Periods	Decades in 21st Century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
low emission scenario (B1)	Dec-Feb	0.4	0.6	0.7	1.0	1.1	1.2	1.2	1.3	1.3
	Mar-May	0.4	0.6	0.8	1.0	1.2	1.3	1.4	1.4	1.4
	Jun-Aug	0.3	0.4	0.5	0.7	0.8	0.8	0.9	0.9	0.9
	Sep-Nov	0.4	0.5	0.8	1.0	1.2	1.3	1.3	1.4	1.4
medium emission scenario (B2)	Dec-Feb	0.4	0.6	0.7	1.0	1.2	1.5	1.6	1.8	2.0
	Mar-May	0.4	0.6	0.8	1.0	1.4	1.5	1.9	2.0	2.2
	Jun-Aug	0.3	0.4	0.5	0.7	0.9	1.0	1.1	1.3	1.4
	Sep-Nov	0.4	0.5	0.8	1.0	1.3	1.5	1.7	1.9	2.1
high emission scenario (A2)	Dec-Feb	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.5
	Mar-May	0.4	0.5	0.7	0.9	1.1	1.3	1.6	1.9	2.2
	Jun-Aug	0.5	0.6	0.9	1.1	1.4	1.7	2.0	2.4	2.8
	Sep-Nov	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.5	1.8

Key	Increase of less than 1°C	Increase between 1-2°C	Increase of more than 2°C

The 2012 Climate Change, Sea Level Rise Scenarios for Vietnam that was prepared by the Ministry of Natural Resource and Environment suggests even higher temperature increases. Under the medium emission scenario (B2) annual average temperature projections for the Quang Nam province are about 1.1°C increase by 2030 and 2.2-2.8°C increase by the end of the century.[59]

Combined with decreases in precipitation between December and May, these temperature increases would contribute to more rapid evapotranspiration and thus decrease runoff and streamflows. Conversely, during the June to November months, the increased temperatures could actually mitigate or lessen the increases in flood events that may be associated with increased rainfall. The South Central Coast and Mekong River Delta are projected to have the highest increases in evapotranspiration in the country, with 10 to 13% increases for 2040-2059 and 18 to 22% for 2080-2099.[60]

In addition to increases in the average temperature and the average maximum temperature, the number of days with a maximum temperature over 35°C is projected to increase from 15 to 30 days over most parts of the country, under the medium emission scenario by the end of the 21st century.

Sea Level Rise

Sea-level rise is projected to be significant and affect approximately 4.4% of the population and much of the road infrastructure along the coast.[61] Sea-level rise and increasing temperatures are also likely to have a

[58] MoNRE, 2009.
[59] MoNRE, 2012.
[60] Government of Vietnam, 2010.
[61] Government of Vietnam, 2010.

negative impact on aquaculture. Although these changes in sea-level will not impact the Song Bung Hydropower project directly, they will have impacts on the region that may ripple through the region. Saltwater intrusion is a concern on rivers where the streamflow is cut off, as it will be daily for the Song Bung Hydropower project. Additionally, winter maize productivity may decrease in the Central Coast region, [62] which could impact the viability of the resettlement and agricultural training portions of the project.

Potential Impacts of Climate Change on Project

PROJECT INFRASTRUCTURE AND OPERATIONS

The impacts of climate change on the Song Bung 4 Hydropower project are uncertain. The best available data indicates that there will likely be an increase in average temperatures throughout the year and seasonal shifts in rainfall. The main climate concerns for the project are increased variability of streamflow that could potentially lead to periodic flooding during the wet season and more severe low flows during the dry season. An increase in forest fires is not mentioned in the available reports; however, increased sedimentation from heavy rainfalls and/or forest fires may disrupt operations at the hydropower plant.

Flooding

If incidents of flooding become more frequent and/or more severe, the dam and the auxiliary infrastructure may be damaged. During flood events when the dam is overtopped, erosion of the dam structure may lead to subsequent dam failure and could result in catastrophic flooding downstream. Concrete dams, like Song Bung, are generally perceived to be more resistant to overtopping failures; however, existing weaknesses, such as weak or fractured rock may be susceptible to erosion and permanent damage.[63] Although the reservoir is expected to help mitigate flooding and the dam is said to be designed for a 5,000-year storm, extreme events or a series consecutive flood events could damage the dam. Furthermore, increased runoff may lead to a sediment build-up that may require changes or increases in dam maintenance and repair.

According to Vietnamese newspapers, A Vuong (one of the eight large hydropower projects on the Vu Gia-Thu Bon river system) was completed in July 2008.[64] During Tropical Storm Ketsana – a strong storm said to be a "5,000-year storm"[65] – in September 2009, A Vuong released water after the reservoir was filled to avoid increased water pressure on the dam. The plant released 140 million cubic meters of water while the lowlands of Vu Gia and Thu Bon rivers were already experiencing alarming flood levels. A Vuong's water discharge at a critical time was blamed for worsening the flooding damage of downstream areas.[66] However, A Vuong operators insisted that they had operated the plant properly, and that the plant actually helped to reduce flooding in the lower areas.[67] Whether A Vuong contributed to or helped reduce flooding during Storm Ketsana remains a heated debate.[68] Two particular concerns were raised, namely the coordination of flood discharges among different hydropower plants in the basin during extreme flooding events, and the need for large hydropower projects to have plans to ensure the safety of local people during flood discharges.

In addition to infrastructure directly related to the dam, roads and the transmission station could be impacted by flooding. Some concern has been expressed about potential flooding of roads to the relocation sites. Access roads to the relocation sites, especially roads that are on steep inclines, may be susceptible to flooding and

[62] Government of Vietnam, 2010.
[63] USBR, 2009.
[64] Hydro World, 2008.
[65] Lao Dong Newspaper, 2008.
[66] Look at Vietnam, 2009.
[67] Talk Vietnam, 2010.
[68] Pham, 2010.

landslides. Farming and agricultural practices of the communities may also be affected by increased flooding or shifts in streamflow.

Variable Flows

Streamflows are likely to become more variable, increasing the intensity of peak flows and decreasing the flow during the dry season. Unlike a run-of-the-river dam, Song Bung 4 has a reservoir that will help level out the seasonal changes in precipitation patterns and allow for more consistent electricity production. However, substantial changes in seasonal patterns could increase uncertainty in river flows and the capacity of the reservoir storage. The tradeoff between power production and environmental flows may become sharper.

Evaporation and Increased Temperatures

Increased surface water temperatures will lead to an increase in evaporation and lower levels of water storage in the reservoir. According to the study on the Zambezi River, a 1°C increase in temperature caused a 2% decrease in runoff. Based on local climate projections, by the end of the 21st century, this may cause approximately a 6% decrease in runoff. Compared to shifts in rainfall, the increase in temperature would likely only have a modest impact. However, it may amplify decreases in rainfall and decrease the potential output and profit of the hydropower plant.

Adaptation Options

The current climate change projections suggest that flooding, increased flow variability, and warmer temperatures may have an impact on the Song Bung 4 hydropower plant; however, given the uncertainty in the data and the precautions that have been integrated into the design of the facility, it is difficult to prescribe specific adaptation options. Information about climate change is constantly evolving and improving. If climate change impacts should prove to be disruptive to service provision, a range of capital and/or operational strategies could be considered, including protection of the dam and assets and/or changes in operations and maintenance.

The available local data is limited. Monitoring the local conditions and evaluating existing and new information will provide the most precise understanding of the range of future conditions. See the Monitoring and Evaluation section for more information.

Flooding

While the project is reported to be built to withstand a 5,000-year storm and will help regulate flooding in the region, shifts in precipitation patterns may lead to an increase in more frequent or more severe flood events. If flooding were to become more frequent or severe, it may be necessary to upgrade project assets to protect them from damage. This may also include more routine tests and maintenance on the dam, the spillway, the headrace, production facility, and the service roads.

In addition to the hydropower plant assets, elements of the relocation plan and practices that were promoted may be compromised. Adjustments to the REMDP and the Gender Action Plan may be required to meet the changing climatic conditions.

Variable Flows

Dam operations and energy production may become more variable due to changes in streamflow. The production expectations may need to be adjusted to meet changes in the available supply. Additionally, environmental stresses downstream will likely be compounded by decreases in streamflow during the dry season.

Evaporation and Increased Temperatures

Increases in extreme heat or the duration of extreme heat may cause more rapid degradation of some infrastructure and auxiliary facilities. Through close monitoring and timely maintenance, these impacts may be identified early enough to recommend repairs and improvements that would avoid significant long-term damage.

Potential Project Impacts on Climate Change

Very few studies have been conducted on the cumulative impacts of hydropower development and climate change in Southeast Asia. However, those few studies that were conducted offer a glimpse of possible impacts of projects like Song Bung 4 on climate change. Most impact assessment studies have followed a highly sectoral approach thereby isolating issues of hydrology from fisheries from other agricultural productivity. In the future, researchers have advised that studies should focus on the cumulative impacts on a broader set of economic and social sectors across a wider geographic area as there are multiple development projects to factor. A review of various studies on the potential for hydropower development and climate change in the Mekong River Basin and the large gaps that remain to be filled in the science was completed in 2014 by GiZ in partnership with experts from the International Crane Foundation and the Mekong River Commission (Beilfuss and Treit, 2014).

Song Bung 4 began operations in October of 2014. In its operation phase, environmental assessments expected regional climate change in terms of increased humidity to result from the construction of the reservoir. Increased humidity may increase the number of pests affecting crop productivity and the health of local people (ADB, 2015) similar to that which occurred in connection with the construction of the Akosombo Dam which created Lake Volta in Ghana.

In most cases, evaluating the potential impacts of a large hydropower installation like Song Bung 4 on climate change would be assessed utilizing the best practice principles developed for integration of climate change considerations into impact assessments (IAIA, 2012). Although this case study has focused on potential climate change impacts on the Song Bung 4, the same principles could be applied to better delineate environmental and social impacts of Song Bung 4 on the regional and especially downstream communities through utilizing the same climate change scenario parameters in Table 4. In the case of Song Bung 4, the environmental and social impact assessment reviewed “global impacts” focusing on GHG emissions which is described more below (SWECO International, 2007a)

Potential for Greenhouse Gas Emissions

Relative to fossil fuel energy sources, hydropower has the potential to contribute to global climate change mitigation. Supporters of large-scale hydropower point to studies from temperate regions which indicate 30-60 times less GHG emissions from hydropower generation than comparable levels of energy generated by fossil fuels (Beilfuss and Treit, 2014). The Kyoto Protocol recognizes some hydropower dams as Clean Development Mechanisms (CDM) thereby allowing a country to qualify for certified emission reduction credits. However, large hydropower reservoirs (especially in the tropics) with significant storage are excluded from CDM credits due to methane (CH_4) release. The data is unclear however, as the World Bank and other researchers have attempted to quantify life cycle emissions – construction to operation and maintenance to dismantling – with a large range in GHG output per kilowatt hour (Beilfuss and Treit, 2014).

The 2007 Environmental Impact Assessment completed on Phase II of the Song Bung 4 estimated that the Song Bung 4 reservoir will become oligotrophic within 3-5 years which would in-turn reduce methane emissions. The report authors estimate that the reservoir will emit CO_2eq/kWh on the low end of the range from 108,000 to 1,620,000 tons or at the lower end of the range of 25–276% of the greenhouse gas emissions from an oil-fired thermal power plant producing the same amount of electricity. Only monitoring can provide a more precise estimate (SWECO International, 2007a).

Monitoring and Evaluation

Monitoring and evaluation will be critical to establish an ongoing understanding of how climate will impact the Song Bung 4 hydropower plant in Vietnam. A comprehensive monitoring and evaluation plan should be done on regular intervals, during and beyond the construction phase of the project, and seek to monitor three elements of the project: (1) the overall project success, (2) environmental and social impacts, and (3) climate variables.

What to Monitor

The May 2008 Report and Recommendation of the President to the Board of Directors includes specifics about the third party monitoring requirement and a design and monitoring framework. Table 5 is an augmented version of the Design and Monitoring Framework that was provided by ADB. Fields in red under the "Climate- Related Monitoring" are suggestions of how the project may supplement their monitoring framework to address climate change considerations.

When to Monitor

To adequately monitor and evaluate the program, it should be done on regular intervals. Currently the monitoring program requires independent consultants to monitor the Environmental Management Plan, the REMDP, and the Gender Action Plan every six month during project implementation.[69] Once the construction is complete, the Environmental Management Plan will be monitored annually for two years.[70]

Intervals

The monitoring interval should be contingent on what element of the project is monitored. Annual or even periodic (every five years) monitoring and evaluation may be a sufficiently frequent to determine the overall project success in meeting the increased power demand and addressing social impacts of the project. However, environmental and climate variables may need to be monitored on a more frequent basis. Environmental impacts may be more prevalent during certain seasons; annual assessments of the environment may not reveal critical impacts that occur during only one part of the year. Similarly, to understand the impact of climate variables on the project, regular monitoring with periodic evaluation would be prudent.

Duration

Currently the project and ADB only require monitoring for environmental and social impacts during construction of the project and for two years after completion. However, the hydropower plant is expected to continue operation for several decades and the people who were relocated under REMDP continue to be affected by the project, even after the implementation phase is complete. Additionally, since climate projections are always made with a degree of uncertainty and the impacts are likely to be observed over a long period of time (decades, not months), monitoring and evaluation of the impact of climate change on the project should be established and continue for the duration of operation.

To understand the real threat and potential impact of shifts in precipitation, streamflow, temperature, and evaporation, local data should be collected on a regular interval. The 2009 Ministry of Natural Resources and Environment report provided regional projections in three-month intervals for each decade through the 21st

[69] SWECO International, 2007a.
[70] ADB, 2008a.

century. While this information is valuable, it obscures local shifts and seasonal shifts – one cannot identify monthly changes, daily trends, or serial events such as multiple heavy precipitation events in a season or extended heat waves. Local daily measurements would provide a more accurate and clear understanding of the climatic conditions on the Song Bung.

In addition to monitoring the local climatic conditions, it would be prudent to implement regular monitoring of the project assets – including the hydropower plant facilities, the relocation settlements, and the auxiliary infrastructure. Regular monitoring of these assets, in conjunction with the climate data would provide a valuable baseline from which to evaluate the operational status for the project.

Table 5: Design and Monitoring Framework[71]

Design Summary	Performance Targets/Indicators	Data Sources/Reporting Mechanisms	Assumptions and Risks	Climate-Related Monitoring
Impact Meeting Viet Nam's increasing power demand in an environmentally sustainable and socially inclusive manner.	No power shortages in Viet Nam by 2015. Reduction in greenhouse gas emissions per unit of economic output and electricity output over 2008–2015 by 10%.	Performance data and reports of the power and energy sectors of Viet Nam by MOIT Published records on greenhouse gas emissions from the power sector by Ministry of Natural Resources and Environment.	**Assumptions** The overall policy framework for attracting new investments to power sector will remain investor-friendly The growth momentum in Viet Nam economy and the growth in demand for power are maintained. **Risk** The financial viability of the sector may deteriorate because of the absence of timely tariff adjustments	Keep records of the local climate and periodically review these in comparison to the electricity output.
Outcome Increased power generation capacity in Quang Nam Province through sustainable use of hydropower, and mitigation of adverse environmental and social impacts.	Addition of 1,000 MW of Hydropower generation capacity in Quang Nam Province without significant outstanding environmental and social issues.	Investment data maintained by MOIT on new investments in hydropower in Quang Nam Province. Records of environments and social performance of hydropower projects in Vu –Gia river basin maintained by Quang Nam peoples committee and NGOs.	**Assumptions** The Project will stimulate investments in new hydropower projects in Quang Nam Province. The innovative features included in the Project to address environmental and social impacts are mainstreamed and incorporated into other hydropower projects in the river basin.	Keep detailed records of local temperature, precipitation, and streamflow Review environmental and social impacts in light of changing climatic conditions.

Outputs 1. Construction and commissioning of the 156 MW Song Bung 4 Hydropower Project and associated facilities 2. Improvement of livelihoods of project-affected persons in a sustainable manner	Completion of Song Bung 4 hydropower project in accordance with the technical design by 2013 Relocation of affected persons by 2012 and improvement of their livelihoods by December 2013 as outlined in the REMDP	Semiannual progress reports to be submitted by the executing agency and supervision consultants ADB project implementation review missions Report from independent monitors on environment and social safeguards	**Assumption** Affected persons are capable of improving their livelihoods in the new sites with the assistance provided by the Project **Risks** Unanticipated geological and other technical risks Weak implementation of the livelihood improvement plan by local authorities	Periodic review of conditions and livelihood of project-affected persons. Consider how extreme temperature and rainfall events may have improved or hampered success of relocation.

[71] ADB, 2008b.

	Implementation of capacity building programs for affected persons as outlined in the REMDP by 2013 No legitimate claims by project-affected persons in Vu Gia river basin during 2008–2013			

Activities with Milestones	**Inputs**
1.1 Completion of the technical design by December 2008. 1.2 Award of main civil work contracts and equipment supply contracts by December 2009 1.3 Construction of 110 m high RCC dam by June 2013 and installation of hydro mechanical equipment by September 2013 1.4 Construction of 3.1 km long tunnel and associated underground waterworks by March 2013 1.5 Construction of power house and installation of electromechanical equipment by September 2013. 2.1 Design of the resettlement sites and associated common facilities in full consultation with affected persons by June 2009 2.2 Relocation of affected persons by December 2012 2.3 Implementation of livelihood improvement program and achieving improved livelihoods during March 2010–June 2012 2.4 Implementation of project-specific gender action plan, including capacity building training program and achieving improvement of women's economic and social condition in the resettlement sites and affected villages by March 2010–June 2013	ADB: $196 million Civil works: $100 million Equipment: $40 million Consulting services: $5 million Financing charges: $19 million Taxes: $10 million Contingencies: $22 million EVN: $49 million Civil works: $19 million Equipment : $6.7 million Project management and Engineering design:$11.7 million Environmental mitigation : $0.6 million Taxes: $5 million Contingencies: $6 million Viet Nam Development Bank: $22.3million Resettlement cost: $17.0 million Contingencies: $1.2 million, Financial charges : $4.1 million

ADB = Asian Development Bank, EMP = environmental management plan, EVN = Viet Nam Electricity, km = kilometer, m = meter, mgmt. = management, MW = megawatts, RCC = roller compacted concrete

Resources

Asian Development Bank (ADB). April 2015. Environmental Monitoring Report. VIE: Song Bung 4 Hydropower Project. Song Bung 4 Hydropower Project Management Board for the Vietnam Electricity and the ADB.

Asian Development Bank (ADB). 2008a. Project Agreement (Song Bung 4 Hydropower Project) between the Asian Development Bank and Electricity of Viet Nam.

Asian Development Bank (ADB). 2008b. Report and Recommendations of the President to the Board of Directors. Available at: http://www.adb.org/sites/default/files/projdocs/2008/36352-VIE-RRP.pdf

Asian Development Bank (ADB). 2012. Song Bung 4 Hydropower Plant Project Description and Documents. Available at: http://www.adb.org/projects/36352-013/main. (Multiple Documents)

Asian Development Bank (ADB). 2013. Photo Essay: Better Lives through Better Resettlement. Song Bung 4 Hydroelectric Project. Available at: http://www.adb.org/news/photo-essay/better-lives-through-better-resettlement. Accessed April 1, 2013.

Beilfuss, Richard and Tran Triet. 2014. A Scoping Study on Climate Change and Hydropower in the Mekong River Basin: A Synthesis of Research. International Crane Foundation for Mekong River Commission and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Vientiane, Lao PDR.

Gebretsadik, Yohannes, Charles Fant, and Kenneth Strzepek. 2012. Impact of Climate Change on Irrigation, Crops, and Hydropower in Vietnam. UNU-WIDER. United Nations University World Institute for Development Economics Research. Working Paper No. 2012/79. Available at: http://www.wider.unu.edu/publications/working-papers/2012/en_GB/wp2012-079.

Government of Vietnam. 2010. Viet Nam's Second National Communication to the United Nations Framework Convention on Climate Change. Available at: http://lowemissionsasia.org/sites/default/files/pdf_file/vnmnc02.pdf

Government of Vietnam. 2006. Viet Nam: Song Bung 4 Hydropower Project Phase II: Summary Environmental Impact Assessment. Prepared for the Asian Development Bank.

Grumbine, R. Edward and Maharaj K.Pandit. 2013. Threats from India's Himalaya Dams. Science Magazine. January 4, 2013. Vol 339. Published by AAAS.

Harrison, G.P., H.W. Whittington, and A.R. Wallace. 2006. Sensitivity of Hydropower Performance to Climate Change.

Huy Hoang. 2012. Song Tranh 2 dam break will affect 31,000 residents. Vietbao Newspaper. October 14, 2012. Available at: http://vietbao.vn/Xa-hoi/Vo-dap-Song-Tranh-2-se-cuon-troi-31000-dan/55492547/157 (in Vietnamese). Accessed April 1, 2013.

Hydro World. 2008. First unit of Vietnam's 210-MW A Vuong begins operation. Available at: http://www.hydroworld.com/articles/2008/11/first-unit-of-vietnams-210-mw-a-vuong-begins-operation.html. Accessed April 1, 2013.

International Centre for Environmental Management (ICEM). 2008. ADB Technical Assistance Socialist Republic of Viet Nam: Capacity Building in the Strategic Environmental Assessment of the Hydropower Project. Prepared for Viet Nam Ministry of Environment and Natural Resources. Brisbane, Queensland, Australia. Available at: http://www2.adb.org/Documents/Reports/Consultant/39536-VIE/39536-VIE-TACR.pdf.

Lam Dinh Uy. Undated. An Evaluation of the ADB's Gender Action Plan for Song Bung 4 Hydropower Project in Zuoih Commune, Nam Giang District, Quang Nam Province, Vietnam. NGO Forum on ADB. Available at: http://www.forum-adb.org/docs/Evaluation-of-ADB-Gender-Action-Plan-Song-Bung-4-Hydro.pdf.

Lan Huong. 2013. Japanese consultancy to assess Song Tranh earthquakes. DTINews Vietnam. March 20, 2013. Available at: http://www.dtinews.vn/en/news/017004/28276/japanese-consultancy-to-assess-song-tranh-earthquakes.html. Accessed April 1, 2013.

Lao Dong Newspaper. 2008. A Vuong Reservoir and Flooding. Available at: http://www.baomoi.com/Ho-A-Vuong-tham-gia-cat-nua-con-lu/144/3350467.epi (in Vietnamese). Accessed April 1, 2013.

Look at Vietnam. 2009. Central Hydropower Plants Worsen Floods. December 12, 2009. Available at: http://www.lookatvietnam.com/2009/12/central-hydropower-plants-worsen-floods-experts.html. Accessed April 1, 2013.

Ministry of Natural Resources and Environment (MoNRE). 2009. Climate Change, Sea Level Rise Scenarios for Vietnam.

Ministry of Natural Resources and Environment (MoNRE). 2012. Climate Change, Sea Level Rise Scenarios for Vietnam.

Pham, Vu. 2010. The Flooding Menace. The Sai Gon Times. November 19, 2010. Available at: http://english.thesaigontimes.vn/Home/features/friday/13800. Accessed April 1, 2013.

Song Bung 4 Hydropower Project Management Board, 2012. Song Bung 4 Hydropower Project: Environmental Monitoring Report (July-December 2012). Available at: http://www.adb.org/sites/default/files/projdocs/2013/36352-013-vie-emr-01.pdf .

SWECO International. 2007a. Song Bung 4 Hydropower Project Phase II Environmental Impact Assessment (EIA). Prepared for the Asian Development Bank and Electricity of Vietnam.

SWECO International. 2007b. Song Bung 4 Hydropower Project Final Report: Main Report. Prepared for the Asian Development Bank and Electricity of Viet Nam.

SWECO International. 2007c. Song Bung 4 Hydropower Project Final Report: Social Management Plan. Prepared for the Asian Development Bank and Electricity of Viet Nam. Available at: http://www2.adb.org/Documents/Produced-Under-TA/36352/36352-VIE-DPTA.pdf.

SWECO International. 2010. Resettlement and Ethnic Minority Development Plan. Volume 1: Cross Cutting Issues. Prepared for the Asian Development Bank, endorsed by Electricity of Viet Nam.

Talk Vietnam. 2010. Hydropower Plant Operators Say They Don't Cause Floods. Available at: http://talkvietnam.com/2010/11/hydropower-plant-operators-say-they-dont-cause-floods. Accessed April 1, 2013.

Talk Vietnam, 2012. Quang Nam cencels 23 hydropower plants. Available at: http://talkvietnam.com/2012/10/quang-nam-cancels-23-hydropower-plants/#.UOz0WOR9IuA. Accessed April 1, 2013.

US Bureau of Reclamation (USBR), 2009. Chapter 11. Flood Overtopping Failures of Dams. Available at: http://www.usbr.gov/ssle/damsafety/Risk/BestPractices/11-FloodOvertopping201108.pdf

World Wildlife Fund (WWF). 2012. Protected Areas: Natural Reserves in the Annamite Forests of Laos and Vietnam. Available at: http://wwf.panda.org/what_we_do/where_we_work/project/projects_in_depth/greater_annamites_ecoregion/about_the_area/protected_places/nature_reserves. Accessed April 1, 2013.

World Bank. 2007. Estimating Global Climate Change Impacts on Hydropower Projects: Applications in India, Sri Lanka, and Vietnam.

Vietnamnet, 2012. Quang Nam: 23 “water bombs” defused. Available at: http://english.vietnamnet.vn/fms/society/50823/quang-nam--23--water-bombs--defused.html. Accessed April 1, 2013.

VietNamNet Bridge. 2012. Four more tremors at Song Tranh hydro-power plant. September 7, 2012. Available at: http://english.vietnamnet.vn/fms/society/43662/four-more-tremors-at-song-tranh-hydro-power-plant.html. Accessed April 1, 2013.

Vietnam River Network, 2012. Song Bung 4 Hydropower Project Site Visit. Available at: http://vrn.org.vn/en/h/d/2012/05/304/Song_Bung_4_Hydropower_Project_Site_Visit/index.html. Accessed April 1, 2013.

Xayaburi Hydropower Project, Laos

A Mekong Giant Catfish caught by local residents on the Mekong River near the proposed Xayaburi dam site (Source: The Irrawaddy, 2012).

Table of Contents

List of Figures

List of Tables

Project Background

INTRODUCTION

Ch. Karnchang Public Company Limited of Thailand (Ch. Karnchang) is building a 1,285 MW hydropower project on the Mekong River's mainstream in Xayaburi district of Northern Laos. The Thai government has agreed to buy 95% of the power generated. The Lao government states that the project will improve the living standards of its citizens. However, many governments, organizations, and people are concerned about the potential impacts of the project on the river ecosystems and livelihoods of people living in the Lower Mekong Basin.

Figure 1. Project Location

In 1995, Laos, Cambodia, Thailand, and Vietnam signed the Mekong Agreement to create the Mekong River Commission (MRC), an intergovernmental body to "promote and coordinate sustainable management and development of water and related resources for the countries' mutual benefit and the people's well-being".[1] The Xayaburi hydroelectric project is one of 12 hydropower projects proposed on the Lower Mekong Basin mainstream. It is the first project to go through a consultation process as required by the Mekong Agreement.

TIMELINE

The project plans indicate that the implementation plan for Xayaburi Project will consist of three phases: a three-year pre-construction phase, an eight-year construction phase, and 22 years of operation and maintenance.[2] The main events of the project development to date are provided below.

May 2007: The Lao government signed a Memorandum of Understanding with Ch. Karnchang, allowing the company to conduct a survey and feasibility study for the development of the Xayaburi Hydropower Project.[3]

October 2008: The feasibility study was completed.[4]

August 2010: Ch. Karnchang completed an Environmental Impact Assessment[5] and a Social Impact Assessment.[6]

October 2010: The Lao government submitted the Xayaburi project to a prior consultation process that would allow the MRC countries (Laos, Cambodia, Thailand, and Vietnam) to review and reach a consensus on whether or not the project should proceed, and if so, under what conditions.[7]

March 2011: The MRC Secretariat completed its review and released a report with findings and recommendations based on the documents submitted by the project developer. It concluded that there is a

---

[1] MRC, 2013a.
[2] Ch. Karnchang Public Company Limited, 2008.
[3] Ch. Karnchang Public Company Limited, 2008.
[4] Ch. Karnchang Public Company Limited, 2008.
[5] Ch. Karnchang Public Company Limited, 2010a.
[6] Ch. Karnchang Public Company Limited, 2010b.
[7] MRC, 2011a.

need for additional baseline data and further study on the transboundary environmental and social impacts of the project.[8]

May 2011: The Lao government hired Finnish engineering company Pöyry to conduct an independent evaluation of the Xayaburi project's compliance with the MRC Design Guidelines for mainstream dams. At that time, Pöyry was nominated to provide engineering services for Xayaburi, raising concerns of conflict of interest (Pöyry later announced its selection to be the Lao government's chief engineer for the Xayaburi dam in November, 2012).[9]

August 2011: Pöyry completed its report, which concluded that the project has "principally been designed in accordance with" the MRC standards, but recommended a number of technical improvements and further studies that need to be conducted. Pöyry however recommended that these studies and improvements could be undertaken during the construction phase.[10]

November 2011: At the request of the Vietnamese government, the MRC Secretariat completed a review of the Pöyry's report. The MRC concluded that even if all technical adjustments recommended by Pöyry were implemented, the project's mitigation measures are still insufficient to address MRC member countries' concerns (mainly on fisheries and sediment transport). The MRC recommended construction be delayed to allow time for conducting transboundary impact studies.[11]

December 2011: The MRC Council (composed of the four governments' Ministers of Water Resources and Environment) agreed to suspend the project until further study is completed.[12]

August 7, 2012: A coalition of 37 Thai villagers filed a lawsuit in Thailand's Administrative Court in Bangkok against five Thai government bodies. The lawsuit claim that the dam will negatively impact Thai people living along the Mekong River in the northeast provinces.[13]

November 2012: The Laos government and the Thai construction company decided to move forward with the project based on the Pöyry's report's findings and recommendations. Ch. Karnchang stated that it would invest $100 million to revamp the design of a fish ladder and the sluice gates for sediment flows to address the environmental concerns cited by the MRC review. A groundbreaking ceremony was held in Laos on November 7, 2012 to mark the start of full construction of the project.[14] By this date, construction on the project was already well underway. The Thai company has built access roads and hauled equipment to the project site.[15]

January 17, 2013: At the 19th meeting of the MRC Council, Laos defended its decision to move forward with the project.[16] Cambodia and Vietnam continued to voice their ongoing concerns. Cambodia demanded that all construction be immediately halted. Vietnam insisted that no dams should be constructed until an agreed upon independent study is completed.[17] A group of development partners to the MRC, including the United States, issued a joint statement at the meeting. They expressed concerns about the social impacts and

---

[8] MRC, 2011a.
[9] International Rivers, 2013.
[10] Pöyry, 2011.
[11] MRC, 2011b.
[12] MRC, 2011c.
[13] Deetes, Pianporn, 2012.
[14] BBC, 2012.
[15] Fuller, Thomas. 2012.
[16] Viraphonh Viravong, 2013.
[17] MRC, 2013b.

environmental risks of the Xayaburi project, especially given that the Lao government has not shared the revised design of the dam with the MRC Secretariat.[18]

2019: The current estimate for the construction to be completed. [19]

FUNDING

The total project cost is estimated to be US$3.5 billion. Ch. Karnchang Public Company Limited of Thailand is implementing the project with private financing. Four Thai banks have expressed interest in providing loans.[20]

PROJECT LOCATION

The Mekong River originates in the Tibetan Plateau and flows through China, Myanmar, Laos, Thailand, Cambodia, and Vietnam before emptying into the South China Sea. The Upper Mekong Basin spans from the Tibetan Plateau to the Lancang Basin in China, while the Lower Mekong Basin consists of Laos, Thailand, Cambodia, and Vietnam.[21] It is one of the world's largest rivers and accounts for up to 25% of the global freshwater catch, provides water for irrigation, and carries sediments that create extremely rich and fertile alluvial soil. The River is a vital source of food security and livelihoods for more than 60 million people living in the Lower Mekong Basin.[22]

The Mekong River basin is rich in biodiversity. It provides vital habitat for rare species including tigers, saola, Asian elephant, Mekong Irrawaddy dolphin, and Mekong giant catfish. However, the region's natural resources and biodiversity are under threat from rapid development of poorly planned infrastructure, climate change, wildlife trade, deforestation, and large-scale hydropower projects.[23]

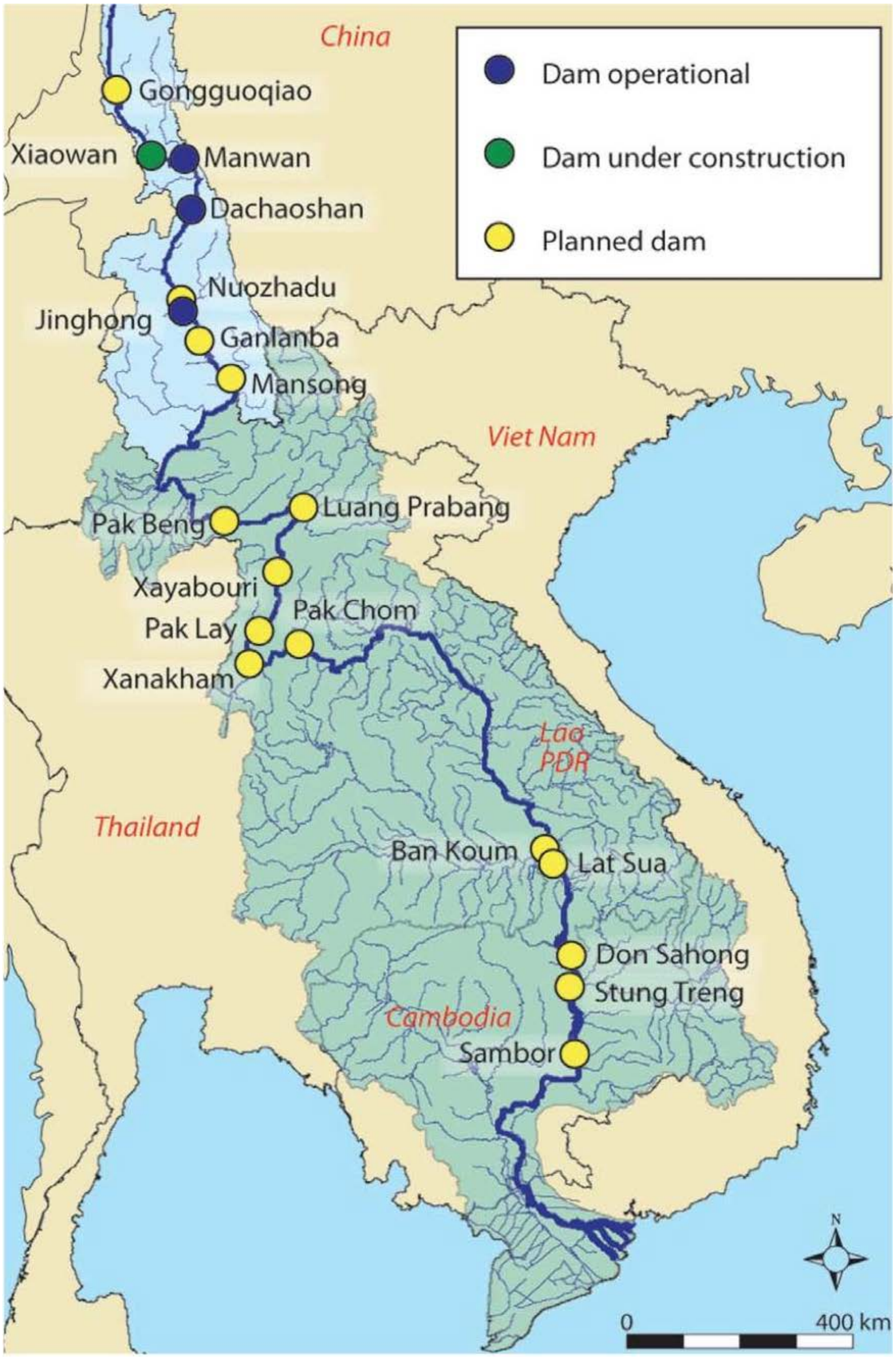
The Mekong River is one of the last large rivers on earth that is not dammed for most of its length. There are four existing and four planned hydropower projects in the Chinese province of Yunnan in the Upper Mekong Basin. Currently there are no dams on the mainstream of the Lower Mekong Basin, downstream from China. However, there are hydropower dams on most of the tributaries in the Lower Mekong Basin.[24]

The Xayaburi Project is located about 100 km downstream from Luang Prabang in Xayaburi district, Xayaburi province[25], Northern Laos. It would be the first in a series of 12 proposed hydropower projects on the mainstream of the Lower Mekong Basin (Figure 1). Ten of these projects would involve construction of dams across the entire river channel – eight in Laos (two of which are on the Lao-Thai border) and two in Cambodia. Another two projects are near the Khone Falls in Laos; one involves partial damming, and the other would construct a diversion around the falls without a dam.[26]

There are a total of 46 villages in the Luang Prabang and Xayaburi provinces that will be affected by the construction of the Xayaburi dam. The people that will be affected are from the Nan, Luang Prabang, and Chomphet districts of Luang Prabang province, and from the Xayaburi district of Xayaburi province. Most of the people who will have to relocate are from Nan district and Xayaburi district.[27] The villages that will be inundated by the reservoir and will have to relocate are shown in Figure 2.

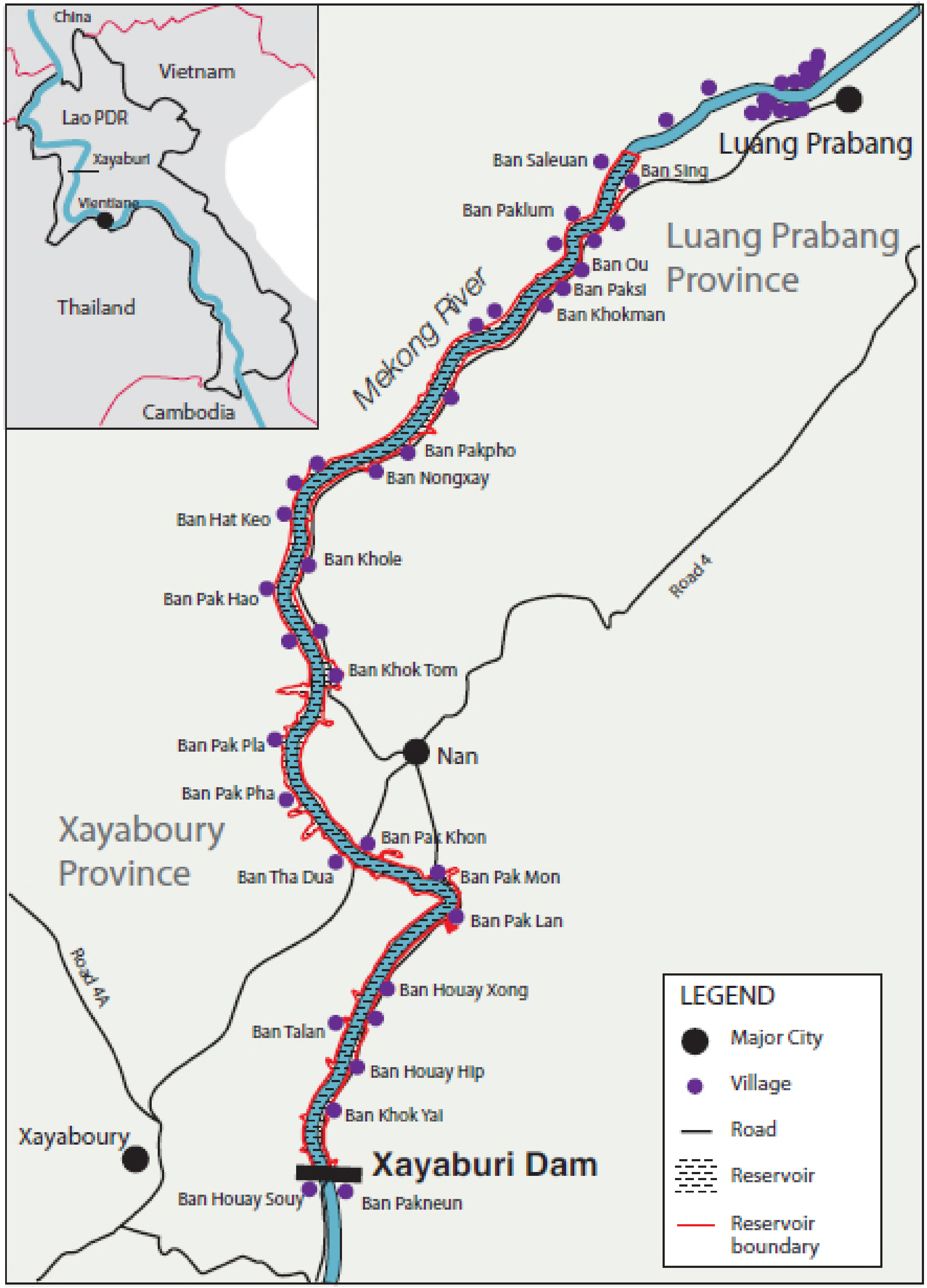
[18] MRC Development Partners, 2013.
[19] Ch. Karnchang Public Company Limited, 2010a.
[20] WWF, 2013a.
[21] MRC, 2013c.
[22] MRC, 2013d.
[23] WWF, 2013b.
[24] MRC, 2011a.
[25] There are multiple spellings – Xayaburi district or Xayaburi province are sometimes referred to as Xayabouri or Xayaboury district/province. This document uses Xayaburi except for in Figure 2.
[26] MRC, 2011a.
[27] Ch. Karnchang Public Company Limited, 2010b.

Figure 2. Locations of Mekong River mainstream dams. Xayaburi would be the first in a series of 12 proposed hydropower projects (including 11 dams) on the mainstream of the Lower Mekong Basin.[28]



[28] Lee and Scurrah, 2009.

Figure 3. Locations of villages that will be inundated by the reservoir of the Xayaburi hydropower project[29]



[29] International Rivers, 2011.

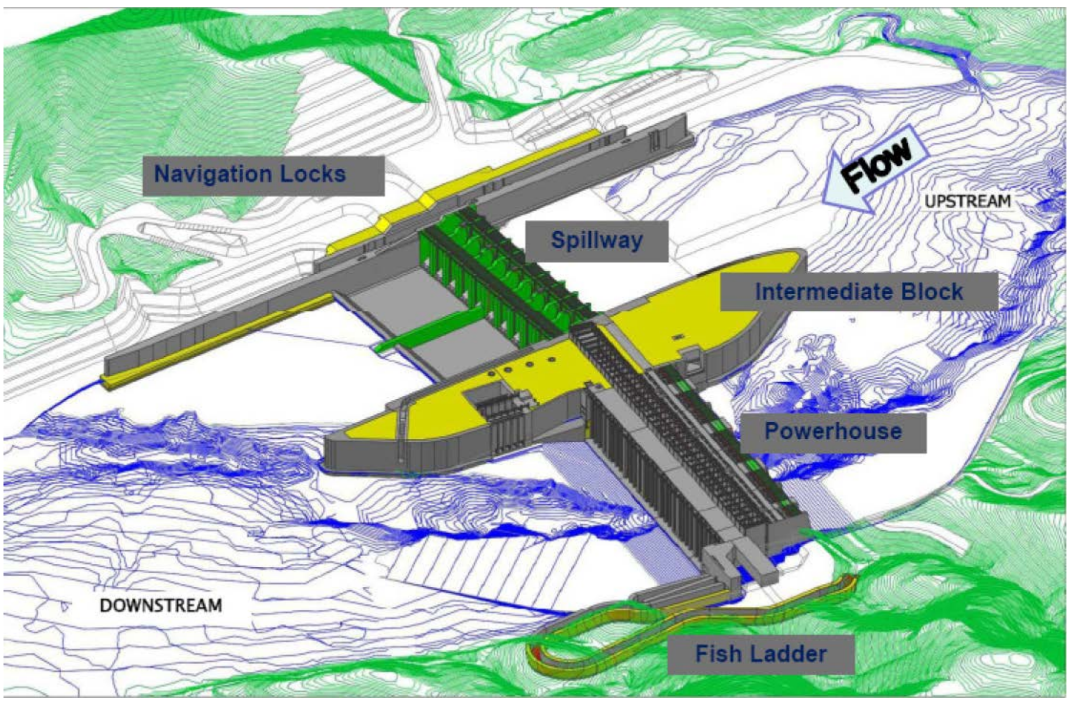
PROJECT ASSETS AND OPERATIONS[30]

The purpose of the project is to generate hydropower. The project will include construction of the following main facilities (see Figure 3):

- A dam structure (820 m long, 32.6 m high, with a rated hydraulic head of 18.3 m);
- A spillway for discharge of river flow greater than the powerhouse discharge capacity that consist of ten radial gates, 19 m wide by 21 m high each; the spillway is designed to discharge floods up to the Probable Maximum Flood, which is 47,500 m^3/s according to the project developer (A 1:10,000 year flood is estimated as 45,000 m^3/s);
- Sluices to flush sediment that may accumulate at the powerhouse inlets;
- Navigation locks;
- Fish bypass facilities (including a fish ladder);
- And seven turbine-generator units of 175 MW capacity or a total of 1,225 MW for export to Thailand, and one unit of 60 MW capacity for use in Laos.

The reservoir impounded behind the dam would be maintained at 275m above sea level to provide the head for power generation. It would extend up the Mekong from the dam to Luang Prabang town, a distance of 100m. The reservoir will have a surface area of 49 km^2 and a gross volume of approximately 1300 million cubic meters.

Figure 4. General Layout of the Xayaburi Hydropower Project



The developer indicated that the Xayaburi dam will be operated as a run-of-the-river project, meaning that reservoir inflow will equal outflow at the plant when measured over a period of several days. However, a daily peak operation of the plant in dry season to maximize revenue is possible, with moderate daily fluctuations of the headwater and tail-water levels. The operation differs in wet and dry season as follows:

Wet Season Operations (typically June to October)

All turbines will operate constantly when river flows exceed the powerhouse capacity (5,140 m3/s). Flushing outlets would be open at all times during high flows. The ten radial spillways would pass the remaining river flow

[30] MRC, 2011a.

up to the Probable Maximum Flood (47,500 m3/s). Spillways would be opened sequentially, starting with the spillways immediately adjacent to the center block, and operated according to flow conditions and optimized spillway operation.

Dry Season Operations (typically November to May)

The project developer suggests a minimum flow of 800 - 1,000 m^3/s at the Xayaburi site, before consideration of upstream flow regulation. In 2010, the minimum flow in this stretch of the Mekong mainstream was reported to be about 650 m^3/s. Regulation of the two upstream Chinese dams, Xiaowan and Nuozhadu, is expected to add 1,000 to 1,200 m^3/s to flow at the Xayaburi site during the dry season. When river flows are less than 5,140 + 3,500 m^3/s, most of the flow would be from a combination of turbines and flushing outlets. At river flows below 5,140 m^3/s, most flow would be through the turbines, with only intermittent use of the flushing outlets. Sand flushing outlets below each turbine unit would be open only when turbines are not operating.

The project developer states that the head water level (normally at 275m above sea level) will be lowered during flood conditions to mitigate the risk of upstream flooding at Luang Prabang city, an important economic hub and tourist destination. However, the Mekong River Commission's review of the project documents indicates that the developer has not provided sufficiently detailed strategies to operate the dam in cases of exceptional floods, emergency events, or for environmental flow or sediment management releases that may be required.

Environmental and Social Impacts

The Xayaburi Hydropower Plant is one of the ten proposed dams on the Lower Mekong Basin mainstream that are part of Laos's national development strategy to expand hydropower to become the "battery of Southeast Asia." These projects are expected to contribute to an improved standard of living for the Lao people through the sale of electricity to neighboring countries (about 95% of the electricity from the Xayaburi project will be sold to Thailand[31]). Despite the project benefits, it will have some significant environmental and social impacts.

Transboundary Concerns[32]

According to a joint statement by the development partners of the MRC, building dams on the mainstream of the Mekong "may irrevocably change the river and hence constitute a challenge for food security, sustainable development, and biodiversity conservation".[33] The specific environmental concerns about the Xayaburi project include its impacts on the river's hydrology, sediment flow, and fisheries and aquatic ecology:

Hydrology: The project developer states that the Xayaburi dam will not change the flow regime due to its run-of-the-river operation. While the MRC review agrees that downstream flows are not likely to be affected, it concludes that the speed of upstream flows near the dam will be greatly reduced. There will be a significant change from the natural fast flows to the expected slow movement within a future reservoir, with potential negative impacts on aquatic ecology. Modeling results show that at a dry season flow of 2000 m^3/s upstream velocities near the dam would decrease to between 5 to 10% of their current values. During a wet season flow of 10,000 m^3/s the equivalent change is estimated to be 30-40%. In addition, there can be rapidly changing fluctuation of water levels downstream of the dam during peak hydropower operation. Such changes in flow regime can have negative impacts on fisheries and ecosystem health.

Flooding: The project is expected to cause only a modest increase in flood water levels in the area 100-200 km upstream of the dam. During flood conditions, the project developer states that the spillway gates will be

[31] Ministry of Planning and Investment of Lao People's Democratic Republic, 2011.
[32] MRC, 2011a.
[33] MRC Development Partners, 2013.

opened to mitigate the risk of upstream flooding at Luang Prabang. The MRC recommended that the opening of spillway gates needs to be carried out carefully to avoid increasing flood flows downstream at a critical time.

Sediment: The project developer states that the run of the river nature of the project will lead to negligible sedimentation in the reservoir. However, the MRC review concluded that there would be significant reductions in flow velocity in the reservoir, which would lead to sediments settling along the length of reservoir (about 100 km long). With the proposed design and operating regime, sedimentation would cause the reservoir to lose about 60 percent of its capacity after 30 years, thus seriously compromising the dam's ability to produce electricity in the medium to long term. Additionally, nearly half of the incoming phosphorous and a third of the nitrogen could be retained in the reservoir. However, according to the MRC review, the loss of sediment and changes in the nutrient balance downstream caused by Xayaburi would be small in comparison to the amount already reduced (up to 45 percent loss) by the large storage dams upstream in China.

Fisheries: The dam and reservoir at Xayaburi may block critical fish migration routes for 23-100 fish species, including five in the International Union for Conservation of Nature Red List of Threatened Species. It is estimated that the six dams in Lao territory north of Vientiane would block downstream migrant species from about 39% of the Lower Mekong Basin's accessible habitat. Additionally, there is a low likelihood that species longer than 150 cm can bypass the Xayaburi dam. As a consequence, there is a strong possibility that the highly endangered Mekong giant catfish will become extinct. The project is not expected to affect the Irrawaddy dolphin near the Khone waterfall further downstream, but this species would be at risk from other proposed projects in that vicinity.

Aquatic Ecology: The reservoir upstream of Xayaburi dam would turn a free-flowing river section into a lake-like system, altering the species composition and biodiversity in the area. Changes in species composition upstream of the dam can potentially affect downstream areas via the food chain. The reservoir can also lead to siltation of the deep pools, resulting in potentially anoxic conditions and reducing the pools' value as habitats for aquatic species. In addition, the permanent inundation of sand bars and river banks would remove nesting and foraging areas for amphibian, reptile, and bird species for the 100km river stretch of the reservoir. These changes in the reservoir and the barrier effect introduced by the dam would cause habitat fragmentation and biodiversity loss in the Mekong River.

The abovementioned potential changes to the river ecosystem will have major implications for people living in the Lower Mekong Basin. About 40 million people, or two-thirds of the population in the region, are involved in the Mekong's fisheries. It is estimated that the six large dams in Lao territory north of Vientiane would result in a 66,000 tons per year reduction in capture. Such a loss would affect the food security and livelihoods of an estimated 450,000 people. Additionally, the Mekong giant catfish, a culturally significant species, could become extinct due to the habitat loss and barrier effect caused by the dam. Other flora and fauna may also be put at risk of extinction due to habitat fragmentation and the dam would undermine the overall health of the river ecosystem upon which communities depend.

Local Concerns[34]

In addition to these transboundary socio-cultural impacts, the project will have local impacts related to the resettlement of people currently living in the immediate project area.

- About 458 households, or over 2,100 people, will need to be fully relocated as their houses, properties, land, and agricultural areas will be flooded.
- About 1,081 households are expected to lose income from agricultural cultivation, granular gold screening, and sand and gravel digging from river banks.

[34] MRC, 2011a and Ch. Karnchang Public Company Limited, 2010b.

- The project will also inundate the sand beach in front of the Chomphet temple, which is used for Songkran festival (Lao New Year) during April 13-16 each year. The area is also used for other social gathering and festivity such as boat racing and Loy kratong, a festival where beautiful decorations are made and then floated on a river.

ENVIRONMENTAL AND SOCIAL COMMITMENTS

The project's Environmental Impact Assessment[35] and Social Impact Assessment[36] outline the measures that will be taken to mitigate the environmental and social impacts of the project. The most notable mitigation measures are discussed below.

Environmental mitigation measures

Fisheries: The project developer commits to mitigate the impacts on fisheries through construction of fish bypass facilities, and assumes that these will effectively allow the passage of migratory fish upstream and downstream. However, the MRC review concluded that the design of the fish ladder for upstream migration as well as the provision for downstream migration of larvae and fry will be ineffective. The MRC recommends alternative designs and operation regimes to improve upstream migration, namely a longer and more natural bypass channel with higher flow rates, operated in conjunction with a separate fish lift and modifications to use the navigation channel for upstream migration. The MRC states that the risk of fish not passing for downstream migration remains "very high" due to the considerable reduction in water velocities in the reservoir that compromises the natural drift of larvae. This is not possible to mitigate and would result in species loss over time.

Sediment: The project developer assumes that the run of the river nature of the project with the sediment flushing regime will lead to negligible sedimentation in the reservoir. However, as noted above, the MRC states that the reservoir can lose about 60% of its capacity after 30 years due to sedimentation, and significant amount of the nutrients entering the reservoir would be trapped. The MRC proposes changing the design of the project, including lowering the sill level of one or more spillway gates, and modifying the flushing and routing operations to reduce reservoir capacity loss from 60% to 30%, and reduce the proportion of phosphorous and nitrogen retained in the reservoir to 5%. These measures will also mitigate the dam's impacts on downstream fish migration. The cost of reduced power generation in the short term from such modifications will need to be balanced with the benefit of protecting the project's capacity in the long term.

In November 2012, the project developer stated that it would invest $100 million to revamp the design of a fish ladder and the sluice gates for sediment flows to address these environmental concerns.[37] However, to date no official report on these modifications has been released by the project developer.

Social mitigation measures

Resettlement and compensation: The project developer states that it will provide resettlement and compensation for people who lose both homes and agricultural areas due to the project construction. The affected households will be relocated to the higher elevation area in the vicinity of the existing villages, except Ban Khok Yai which will be moved to Ban Houay Hip about 1.2 km away.

The developer also promises to provide (1) community resources, properties, and cultural sites, such as agricultural land, electricity, water resources, transportation routes, government offices, schools, worship sites, cemeteries, (2) income and livelihood restoration assistance, (3) private infrastructure, and (4) institutional strengthening and capacity building program for those directly concerned with the implementation and management of the project's Resettlement Action Plan.

[35] Ch. Karnchang Public Company Limited, 2010a.
[36] Ch. Karnchang Public Company Limited, 2010b.
[37] BBC, 2012.

- The project will provide compensation for people who lose only cultivated land because of the project construction. The project will try its best to provide suitable replacement land with equivalent productive capacity and in acceptable locations. If this is not possible due to the scarcity of arable land, the project says it will look into options for developing new lands and/or more intense use of land.
- The project will develop and implement a livelihood restoration program. However, it is unclear from the project's Social Impact Assessment whether this program is designed for only people who lose houses and/ or agricultural land, or for all people whose livelihoods were affected by the project (including those involved in gold screening/ sand and gravel gathering from river banks).
- Finally, the project will build an area of about 10 ha between the Tham Temple and Had Siew Temple to compensate for the inundated sand beach in front of Chomphet temple.

CUMULATIVE IMPACTS

The transboundary effects and cumulative impacts resulting from multiple dams have been analyzed in two studies, namely the *MRC Basin Development Strategy for the Lower Mekong Basin*[38], and the *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream*.[39]

MRC Basin Development Strategy for the Lower Mekong Basin

According to the Basin Development Strategy, there are a total of 49 hydropower projects that are either in operation, under construction, or already firmly committed in the Mekong Basin. Eight of these are in China and 41 are on the Lower Mekong Basin tributaries. An additional 12 mainstream projects (one of which is Xayaburi) and 30 tributary dams have been proposed in the Lower Basin. The MRC recognizes the high potential economic benefits from such hydropower developments, but also emphasizes the significant associated risks and costs that must be managed and mitigated.

Strategic Environmental Assessment of Hydropower on the Mekong Mainstream

The specific impacts, both positive and negative, of the 12 proposed mainstream projects are elaborated in the *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream*. The main findings of the study are summarized as follows:

Power Generation and Security: The 12 dams will significantly contribute to power generation in the Lower Mekong Basin, representing 23% of the technical hydropower potential in the four Lower Mekong Basin countries. About 90% of the power generated will be exported to Thailand and Vietnam, where the demands originate.

Economic Development and Poverty Alleviation: The projects will bring significant economic benefits for the regional power sector, 70% of which would go to Laos and 30% to Cambodia. During the concession period (typically 25 years), only 25-31% of gross revenues would accrue to the national host governments (the rest would go to project developers and financers); this percentage would rise to almost 100% after concession period.

If properly managed, these revenues could contribute significantly to economic development in Laos and Cambodia. However, the current institutional capacity will not be sufficient to ensure that national benefits will be transferred to the local level.

The fisheries and agriculture sectors will suffer significant net loss from the hydropower developments. Potential loss is estimated to be $500 million/ year, while potential benefits from reservoir fisheries and new irrigation potential is expected to be only $30 million/ year. The loss would be even greater if economic impacts on coastal and delta fisheries are included.

[38] MRC, 2011e.
[39] ICEM, 2010.

Even with mitigation measures conventionally associated with hydropower projects in the region, the 12 projects would likely contribute to a growing inequality in the Lower Mekong Basin countries, as benefits of hydropower projects would accrue to electricity consumers, while most costs would fall on poorer communities who are dependent on natural resources. Poverty in the short to medium term would be worsened as a result. Vietnam and Cambodia would suffer net losses in the short to medium term due to the impacts on fisheries and agriculture.

Ecosystem Integrity and Diversity: The dams would disrupt the connectivity of the Mekong ecosystems, compartmentalizing the River into smaller and far less productive units. The projects will significantly affect flooding regime, converting 55% of the Lower Mekong River into reservoir and potentially causing substantial and rapid fluctuations in downstream water levels at a daily and even hourly time-step. There can be massive reductions in sediment transport and disruption of the hydro-ecological seasons. The dams would also cause irreversible degradation of the Mekong River ecology and permanent losses in aquatic and terrestrial biodiversity that cannot be mitigated and compensated.

Fisheries and Food Security: The dams would cause increased food insecurity for millions of people, especially populations living within 15 km of the Mekong River who will experience reduction in capture fisheries, and net loss of subsistence agriculture and river bank gardens.

Based on these findings, the *Strategic Environmental Assessment* recommended delaying the proposed mainstream projects by ten years (to 2020) to allow sufficient time for further studies.

Of these 12 proposed mainstream projects, Xayaburi is the first submitted for consideration by the MRC. It is therefore an important test for the MRC's prior consultation process and regional cooperation in implementing sustainable development in the Mekong River. In particular, many are concerned that the construction of Xayaburi will set the precedent for the 11 other proposed projects, which together with Xayaburi will cause large transboundary and cumulative impacts as described above.

ADHERENCE TO COMMITMENTS

Environmental commitments

Ch. Karnchang indicates that it will carry out the environmental mitigation measures described in its Environmental Impact Assessment (2010). In addition, the company states it will implement the recommendations made by the Pöyry's report (2011) to improve the project's compliance with the MRC design guidelines for mainstream dams.[40] However, there are concerns that the adjusted measures are still inadequate to address the project's potential environmental impacts, especially on fisheries and sediment transport.[41] In November 2012, Ch. Karnchang announced that it would invest $100 million to revamp the design of the fish bypass facilities and sediment sluice gates. However, the revised design has not been released and shared with the MRC and the public.

It is therefore unclear that the environmental commitments made by Ch. Karnchang are sufficient to mitigate the expected impacts of the project. Furthermore, since the project is in early construction phase, there is little information available regarding its adherence to the environmental commitments made in the Environmental Impact Assessment and based on the recommendations by Pöyry.

Social commitments

In its Social Impact Assessment, the project developer states that monitoring of the resettlement implementation activities will be conducted by an independent agency. This agency will perform regular monitoring until the end of the resettlement program, including the completion of a post-implementation

[40] International Rivers, 2012a.
[41] International Rivers. 2012b.

evaluation study. However, the project developer did not specify the time interval between each monitoring effort during the project implementation phase.

The monitoring will focus on the outcome of resettlement implementation. It will include verification of such commitments as payment of compensation, preparation and adequacy of resettlement sites and house construction, provision of employment and training, and infrastructure repair, relocation, or replacement. The independent agency will also assess the effectiveness of the grievance redress mechanism and survey the living standard of the project affected peoples to see if they are at least as well-off as before the resettlement.[42]

According to the non-profit organization International Rivers, the project's resettlement process began in early 2012. Ch. Karnchang relocated the first village, Ban Houay Souy, in January 2012. A total of about 333 people were moved to a newly constructed village near Xayaburi town, 17 km away from their old home. During its visit to the resettlement site in June 2012, International Rivers found that Ch. Karnchang's implementation of its resettlement commitments was insufficient. Livelihoods of many peoples had not been restored and food insecurity remained a serious concern.

Specifically, the company provided the villagers with half-completed houses, forcing residents to finish the construction at their own expense. Some complained that in the rush to complete the houses the company used wet wood, which had bent and caused cracks in the houses and was infested with termites in some cases.

As the new location is far from the Mekong River, villagers found it hard to fish and no compensation had been provided for the loss of fisheries. The company only agreed to give each household 0.75 hectares of agricultural land, significantly less than the two hectares that households owned on average in the old village. Villagers were concerned that the allocated land would be insufficient to grow food. As of June 2012, many residents had also not received compensation for their lost land, riverbank gardens, and income from gold panning.

The company gave each family a monthly allowance of 120,000 kip (about US $14) per person. It also provided each family with a single source of income, such as duck raising, pig farming, or mushroom growing. However, the income and allowance are insufficient to cover the cost of living, which is higher than in the old location due to several additional expenses. One is the cost of electricity – the villagers once had access to inexpensive, renewable energy through micro-hydro generators on the Mekong tributaries, while they faced higher electricity costs in the new village. Other additional expenses are the cost of transportation to Xayaburi town market and monthly water bills.

These issues in Ban Houay Souy raised concerns about the adequacy of the resettlement process. During the same visit, International Rivers also interviewed households from 14 other affected villages (about to be relocated but not yet moved as of June 2012). It concluded that Ch. Karnchang did not fully comply with both the Laos' 2005 Resettlement and Compensation Decree and the World Bank's Resettlement Standards to which the company has committed. Additionally, the government of Laos has not fulfilled its commitment to study the project's transboundary impacts as required by the 1995 Mekong Agreement.[43] Many concerns regarding the impacts on food security in Cambodia, Vietnam, and Thailand thus remained unaddressed.

Background on Climate Change and Hydropower Projects

Hydropower is widely accepted as a good alternative to fossil fuels that can provide clean energy to growing economies. Currently, hydropower meets approximately 20% of the global energy demand and the output is anticipated to increase three-fold by 2100.[44] A number of studies have explored the impact of climate change on

[42] Ch. Karnchang Public Company Limited, 2010b.
[43] Herbertson, Kirk. 2012.
[44] Harrison et al. 2006.

hydropower projects. The extent of the research is largely limited to assessing the economic output under changing hydrological conditions and global markets.

A World Bank commissioned study of the impacts of climate change on hydropower projects in India, Sri Lanka, and Vietnam focused on three main impacts of climate change on hydropower:[45]

> (1) **Temperature and precipitation shifts** may alter the discharge of a river and impact the amount of energy produced by the project. Hydrological periodicities and seasonality changes can affect the operations (such as peak versus base load) of the hydropower plant.
>
> (2) An expected increase in climate variability may trigger more extreme events, including **floods and droughts,** which could impact the energy production capacity.
>
> (3) Changing hydrology and extreme events may change **sediment risks** which could raise the risk of exposure to turbine erosion. In addition to major, destructive events, smaller changes could lower turbine and generator efficiency, resulting in output declines.

The studies largely focus on the changes in precipitation and temperature. Changes in precipitation are positively correlated with runoff – an increase in precipitation results in higher runoff. Changes in temperature are negatively correlated with runoff – higher temperature increases evaporation and results in lower runoff (assuming no change in precipitation).[46] Shifts in precipitation have a more direct impact on runoff, than changes in temperature. The Harrison et al. 2006 study of the proposed 1600 MW Botoka Gorge project for the Zambezi River on the Zambia-Zimbabwe border estimated that a 20% increase in rainfall resulted in a 46% increase in runoff. Comparatively, a 1°C increase in temperature caused a 2% decrease in runoff. Additionally, the study found that the changes in runoff were more dramatic during high flows (due to the inability of wet soils to absorb more water), than during low flows.[47] While these numbers are specific to the Zambezi River project and cannot be applied to Xayaburi or other hydropower projects, the direction and amplitude may be applied:

- An increase in precipitation will likely cause a notable increase in runoff;
- An increase in temperature will likely cause a modest decrease in runoff; and
- Changes in runoff will likely be more significant during high flows than during low flows.

The impact of shifts in river discharge varies between generating methods – for example, a run-of-the-river station with limited storage capacity (like the Xayaburi project) would be more sensitive to seasonal changes and hydrological periodicities than a conventional plant with a dam and reservoir. Storage capacity will help reduce the impact from changes in the timing and intensity of precipitation events, allowing for more consistent electricity production.

In addition to shifts in river flows, extreme events may impact the viability of a project. Extreme events may cause direct damage to the facilities, which could result in costly repairs or facility destruction. Changes in sediment could also have cumulative impacts on the efficiency and operation of the facilities. Wildfires may result in increased erosion and sediment risk to the facility. In summary, the four climate change factors that are likely to directly impact the operation of a hydropower plant are: changes in precipitation, temperature, extreme events, and wildfires.

---

[45] World Bank, 2007.
[46] World Bank, 2007.
[47] Harrison et al. 2006.

Local Conditions

CURRENT LOCAL CLIMATE

The Lower Mekong Basin has a tropical monsoonal climate with a wet season from June to October and a dry season from November to May. Annual average temperatures range from 30°C to 38°C. The distribution of mean annual rainfall in the Basin follows an east-to-west gradient. In the Lower Mekong Basin, the uplands in Laos and Cambodia receive the most precipitation (3,000 mm), and the semi-arid Khorat Plateau in northeast Thailand the least (1,000 to 1,600 mm).[48]

CLIMATE CHANGE PROJECTIONS

Temperature and Precipitation

Climate change is projected to cause increased temperatures and alter the precipitation patterns of the Mekong River Basin. A recent study conducted for the Mekong River Commission (Chu et al., 2010) analyzes the impacts of climate change and development on the Mekong River flow regimes. The study focuses on temperature and precipitation changes, and does not cover sea level rise. Global climate projections for two emissions scenarios, A2 (high) and B2 (low)[49], were downscaled to the Mekong region using the PRECIS[50] modeling system. The projections are developed for the 2010-2050 period and compared to a baseline of observed conditions in 1985-2000. The key results of the study are presented below.

Precipitation and runoff patterns

Table 1 summarizes the projected changes in precipitation in the Lower Mekong Basin by 2050 compared to a 1985-2000 baseline. The **mean annual rainfall** is projected to increase under both A2 and B2 scenarios. The area around Xayaburi is projected to see an increase of 1-11% in annual average rainfall (Figure 3).

The **wet season rainfall** is also projected to increase. While **dry season rainfall** is expected to remain unchanged for the Lower Mekong Basin as a whole, it is projected to increase in the upper parts of the Lower Basin. Overall, the upper area of the Lower Mekong Basin (where Xayaburi is located) is expected to experience an increase in average precipitation during both the wet and dry seasons.

The **annual mean flow** of the Lower Mekong River is projected to increase in both the wet and dry seasons, with an increase of 4-13% for the wet season and 10-30% for the dry season. The increased flow will boost water availability in the dry season, but will likely increase the risk of flooding in wet season. The areas affected by flooding due to rainfall and upstream freshwater flow from the Mekong River Basin (excluding sea level rise effects) are estimated to increase by 9%. Flooding is also anticipated to increase in intensity – the area where the flooding depth is high (e.g., 2 m) could increase by almost 40%. Increased flood risks will have the greatest impact in downstream catchments on the mainstream of the Mekong River, including the Tonle Sap area in Cambodia and Mekong Delta in Vietnam. The plain areas adjacent to the Mekong River in Laos will also be affected.

In addition, the increased temperature is projected to result in earlier melting of **snow** in the Upper Mekong Basin. The contribution of snowmelt to the annual water runoff at the Chinese-Lao border is projected to increase from 5% to 8% by 2050. The contribution of snowmelt to runoff is more significant in the dry season, especially in March when there is highest snowmelt and low rainfall – snowmelt amounts to 70% of the flow at the Chinese-Lao border in March, but this percentage is projected to remain unchanged as both flow and

[48] MRC, 2013e.
[49] A2 is the relatively higher emission scenario, and B2 is the relatively lower emission scenario.
[50] PRECIS: Providing Regional Climates for Impacts Studies, a regional climate modeling system.

snowmelt are predicted to increase. As the snowmelt effect becomes of minor importance at stations further downstream, its impact on the Xayaburi project is minimal.[51]

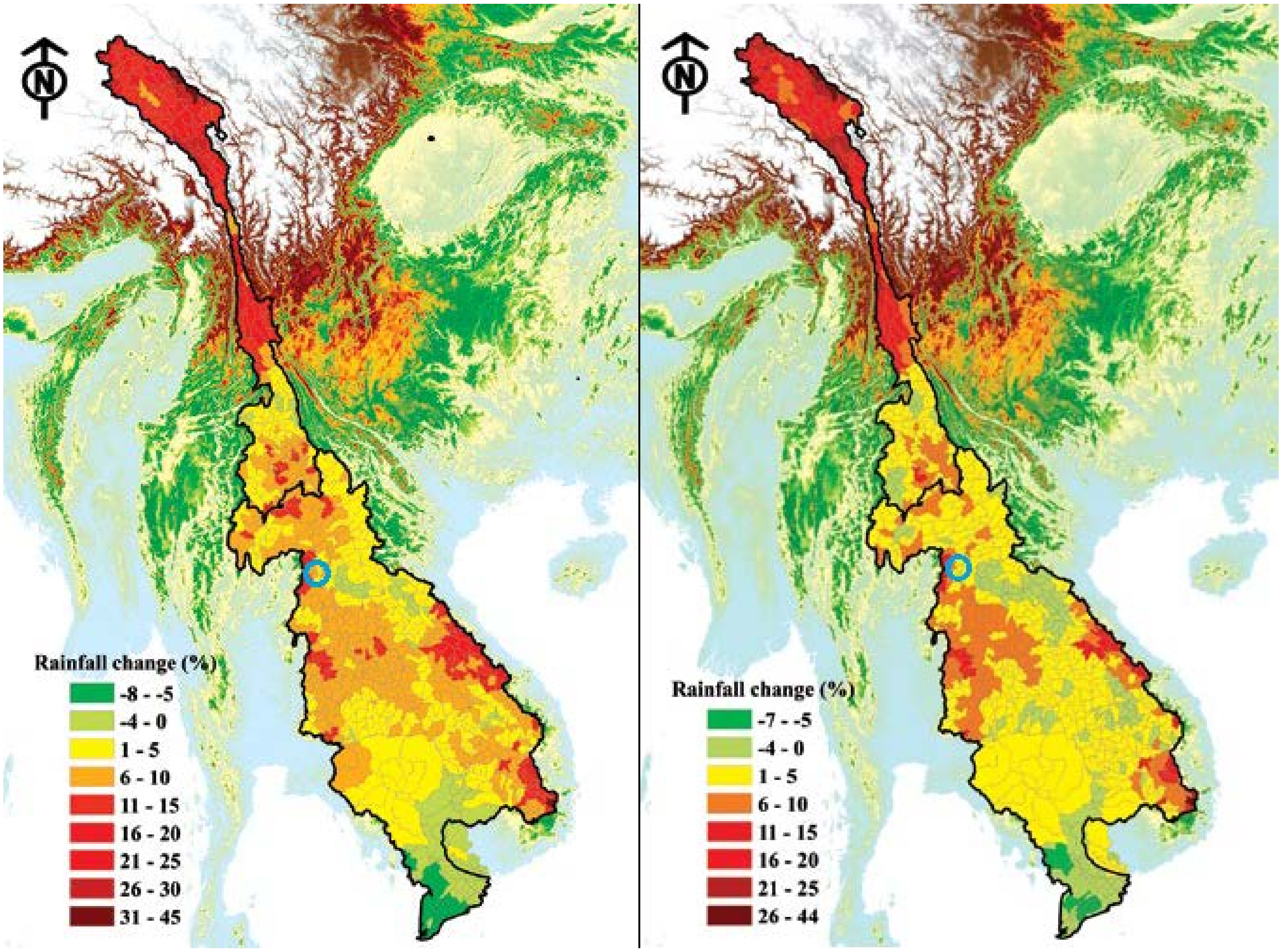
However, a comparison of nine different studies shows that projections in precipitation vary widely (Table 2). The annual and seasonal precipitation increases or decreases depend on selection of the General Circulation Models (GCM) or downscaling model, and of the type of data used (observed data in the basin, data from the global dataset, or data from models). There is thus a high degree of uncertainty in precipitation projections, and caution needs to be taken when using results from any climate change scenario analysis, including those presented in this section.

Table 1. Mean annual and seasonal change (%) in Lower Mekong River Basin in Scenario A2 and B2 (2010-2050) compared with observed baseline (1985-2000)[52]

	Emissions scenario A2	Emission scenario B2
Mean annual rainfall	4.5	2.4
Wet season rainfall	4.0	3.3
Dry season rainfall	7.9	-2.8

[51] Chu et al., 2010.
[52] MRC, 2011d.

Figure 5. Change in mean annual sub-basin precipitation (%) during 2010-2050 compared to 1985-2000 for Scenario A2 (left) and B2 (right) (The blue circle indicates the location of the Xayaburi project)[53]



Average annual temperature

The average annual temperature is projected to increase by 0.7°C in the Lower Mekong Basin by 2050 under the A2 scenario, and by 0.8°C under the B2 scenario. This is equivalent to an increase of about 0.020-0.023°C per year, which falls in the range of projected temperature increases (0.01-0.06°C per year) from eight other studies (see Table 2 for a full comparison of results between Chu et al. (2010) and these eight studies).

[53] MRC, 2011d.

Table 2. Comparison of projected climate change from different studies (Adapted from Chu et al. (2010))

Authors	**Snidvongs et al. (2003)**	**Hoanh et al. (2003)**	**Ruosteenoja et al. (2003)**	**Helsinki University and START (2008)**	**Eastham et al. (2008)**	**Mac Sweeney et al. (2008a & 2008b)**	**ADB (2009)**	**Johnston et al. 2009**	**Chu et al. (2010) (reported in this study)**
Location	Lower Mekong	Mekong Basin	Southeast Asia	Lower Mekong	Lower Mekong	Cambodia, Vietnam	Thailand, Vietnam	Greater Mekong Subregion	*Mekong Basin*
Models	CCAM	HADC	7 GCMs	ECHAM4-PRECIS	11 GCMs	15 GCMs	MAGICC (GCM)	ECHAM4-PRECIS	*ECHAM4-PRECIS*
Scenarios	Not specified	A2, B2	A1F1, A2, B1, B2	A2	A1B	A2, A1B, B1	A1F1, B2	A2, B2	*A2, B2*
Period	Doubled CO_2	1960-2099	1961-2095	1960-2099	1951-2000 and 2030	1970-2090	1900-2100	1960-2049	*1985-2050*
Projected changes in annual rainfall	Not explicitly quantified	-1.64 to +4.36 mm/year	Either >0 or <0, depends on models and scenarios. Almost always insignificant	Increase (not explicitly quantified)	+0.1 to +9.9 mm/year	+0.3 to +0.6 mm/year	1990-2050: +1.26 to -1.62 mm/year (B2); 0.66 to -1.14 mm/year (A1F1) 1990-2100: +3.27 to +4.91 mm/year (A1F1) and -1.63 to -2.45 mm/year (B2)	No significant change at the whole Greater Mekong Subregion scale	*+ 1.2 (B2) to +2 (A2) mm/year*
Temperature	+0.01 to +0.03/year	+0.026 to +0.036°C/year	+0.01 to +0.05°C/year	Increase (not explicitly quantified)	+0.012 to +0.014°C/ year	0.00 to +0.06°C/year	+0.03 to +0.06°C/year	+0.03 to +0.06°C/year	*+0.020 to +0.023°C/year*

Sea level rise

As Laos is a landlocked country, the Xayaburi project is not affected by sea level rise. However, hydropower developments in Laos may exacerbate the impacts of flooding and sea level rise in downstream areas, while having uncertain impacts on saline intrusion.

Sea level rise in the Mekong Basin will mostly occur in the Mekong Delta of Vietnam, where the Mekong River flows into the South China Sea. The average sea level along Vietnam coast is projected to rise about 49-64 cm under the low emission scenario (B1), 57-73 cm under the medium emission scenario (B2), and 78-95 cm under the high emission scenario (A1Fi) by 2100.[54] Sea level rise is going to increase the areas that are vulnerable to flooding in Vietnam. During extreme flood events, water discharge from upstream hydropower plants in Laos, if released at a critical time, can increase flood flows downstream and worsen the flooding damage in Vietnam.[55]

In addition, sea level rise is expected to cause increased saltwater intrusion in the Mekong Delta, with significant impacts on agriculture, aquaculture, and capture fisheries.[56] An accumulation of dams on the river could reduce the volume of water and sediment that reach the Mekong Delta, making it more vulnerable to sea level rise and saline intrusion.[57] However, a MRC study found that hydropower development can help reduce the areas with saltwater intrusion through increasing river flow during the dry season, but cautioned against this conclusion due to the uncertainty in precipitation projections.[58]

Extreme events

Countries in the Lower Mekong Basin experience periodic floods and droughts that cause devastating human and economic losses. The frequency, severity, and duration of these events will likely increase due to climate change.

According to the MRC, tropical storms are also expected to increase in frequency and intensity in the region.[59] However, there is great difficulty in predicting these changes and much uncertainty remains. The IPCC's most recent report on extreme events states that there will likely be a decrease or no change in the global frequency of tropical storms but an increase in their intensity. Furthermore, the IPCC notes that while the global frequency will either decrease or remain unchanged, the frequency of the most intense storms can increase substantially in some ocean basins.[60]

Impact of Climate Change and Development on the Mekong flow regime

In addition to climate change, Chu et al. (2010) also considers the impacts of development on the Mekong flow regime. The development scenario used in the assessment is the Lower Mekong Basin 20-year Plan (which includes 8 hydropower projects in China as well as 12 mainstream hydropower projects, 71 tributary hydropower projects, and expected water supply and irrigation demand by 2030 in the Lower Mekong Basin). In the absence of further development, climate change will likely increase **river flow** in both the wet and dry seasons as mentioned above. Development is expected to even out the annual flow cycle, thereby counteracting climate impacts during the rainy season and reinforcing them during the dry season. The effects of climate change and development on the Mekong flow, both separately and combined, are presented in Table 3.

[54] Vietnam Ministry of Natural Resource and Environment, 2012.
[55] MRC, 2011a.
[56] MRC, 2013f.
[57] WWF, 2013c.
[58] Chu et al., 2010.
[59] MRC, 2009a.
[60] IPCC, 2012.

Table 3. Summary of climate change and development impacts on the Mekong river flow[61]

Projected flow change	Under Climate Change	Under Development	Under Climate Change & Development combined
High-flow season	+2 to +11%	-7 to -17%	-13 to +3%
Low-flow season	+18 to +30%	+30 to 60%	+40% to +76%
Annual flow	+6 to +16%	-3 to -8%	+2 to +12%

However, the study states that the combined effects of climate change and development on the Mekong flow regime are complex and many uncertainties remain. For example, while the mean flow is projected to increase over a long period, annual variation can be large, and there can be years with decreased flow in dry season.

With regards to **flooding**, climate change is projected to increase flood risks in the Lower Mekong Basin. While development can help reduce the area of flooding (for example though reservoir storage), climate change is expected to increase these areas in worse years. Finally, the study finds that climate change can increase areas with **saline intrusion** on the Mekong Delta while development can help reduce these areas, since hydropower plants can increase river flow during the dry season. However, the uncertainty in precipitation projections needs to be considered when reaching these conclusions on saline intrusion.

Potential Impacts of Climate Change on Project

PROJECT INFRASTRUCTURE AND OPERATIONS

The current climate change projections show that Xayaburi will likely experience an increase in temperature and in both wet and dry season mean precipitation. There is projected to be an increase in the incidence, intensity, and duration of extreme flood waters in the Lower Mekong Basin. Drought can also become more frequent and intense, potentially causing higher occurrence of forest fires. These changes can impact the infrastructure and energy output of the Xayaburi hydropower project.

Flooding

During extreme flooding events, the dam and the auxiliary infrastructure such as intake facilities may be damaged. Other infrastructure not directly related to the dam, such as roads and the transmission station, could be impacted by flooding. For example, the flash floods and prolonged floods resulting from the Xangsan Storm in 2006 caused damages to the power house of Namtha & Namlung hydropower project in Nalae district, Luang Namtha province of Laos (north of the Xayaburi project, Figure 5). The damage cost approximately 6.5 billion kip, or US$0.65 million.

If the dam is overtopped during extreme floods, erosion of the dam structure may lead to subsequent dam failure and could result in catastrophic flooding downstream. Concrete dams, like Xayaburi, are generally perceived to be more resistant to overtopping failures; however, existing weaknesses such as weak or fractured rock may be susceptible to erosion during overtopping flows, and can lead to foundation loss and permanent damage of the dam.[62] Dam overtopping is also unlikely if the spillway has been designed to discharge floods up to the Probable Maximum Flood[63], which is the case for Xayaburi (According to the project developer, the

[61] MRC, 2011d.
[62] USBR, 2009.
[63] USBR, 2009.

Probable Maximum Flood exceeds a 1:10,000 year flood at Xayaburi)[64]. Nevertheless, the Mekong River Commission recommended that the project should undertake a dam-break analysis to confirm that the main structures can withstand overtopping in the event of extreme flood or upstream dam break. This assessment should incorporate all proposed mainstream dams above the Xayaburi site and different climate change scenarios developed by the MRC.[65] It appears that no such assessment has been completed by the project developer to date.

Figure 6. Location of Luang Namtha province in relation to the Xayaburi Dam.

Changes in flows

The Mekong river flow is projected to increase in both the wet and dry seasons. As a run-of-the-river project with limited storage capacity, Xayaburi will be unable to take advantage of the increased flow for higher electricity generation. Furthermore, climate change can cause an increase in seasonal flow variability, which can disrupt the expected water supply patterns.

The projected increased runoff may also lead to sediment build-up in the reservoir that may require changes or increases in dam maintenance and repair. It is estimated that with the proposed design and operating regime the reservoir would already lose about 60 percent of its capacity after 30 years due to sedimentation. Climate change can further exacerbate sedimentation and reduce the dam's ability to produce electricity.[66]

[64] MRC, 2011a.
[65] MRC, 2011a.
[66] ADB, 2012.

Increased Temperature and Surface Water Evaporation

Increased temperature can lead to higher surface water evaporation and lower levels of water in the reservoir. However, this impact is minimal compared to the increased flow due to increased precipitation. According to a study by the Asian Development Bank, temperature changes usually have no significant impact on hydropower plants.[67]

Forest Fires

An increase in the occurrence and/or intensity of forest fires may cause increased sedimentation of the reservoir. However, limited data exist on forest fires and their impacts on hydropower in Laos and other Lower Mekong countries. This impact appears to be of lower priority to the Xayaburi project compared to changes in precipitation and runoff patterns.

Adaptation Options

The current climate change projections suggest that flooding and increase in flow level and variability are the main factors that may affect the Xayaburi hydropower project. Since hydropower is a long-term investment with a typical lifetime of 50-100 years, it is important to incorporate climate change into the design of a new hydropower project like Xayaburi. Local climate change projections for the Lower Mekong Basin have been developed; however, there is considerable uncertainty in precipitation changes (Table XX), making it difficult to prescribe specific adaptation options. Nevertheless, there is a need for the project developer to consider the likely range of changes in climate based on the existing studies. This will help improve confidence in planning and reduce costs over the long term. Additionally, it is important to monitor the local conditions and evaluate new information to improve understanding of the future conditions and determine the appropriate adaptation actions (See the Monitoring and Evaluation section for more information).

Flooding

While the project is reported to be built to withstand the Probable Maximum Flood (an approximately 10,000-year event), the projected increase in the frequency and severity of flooding in the area may require an even more robust design of the dam and associated infrastructure. The Mekong River Commission recommended that the project developer conduct a dam break analysis, which should take into account all dams upstream of the Xayaburi site and different climate change scenarios developed by the MRC. More routine tests and maintenance of the dam, the spillway, production facility, and the service roads may also be necessary. In addition, it is important to coordinate the opening of spillway gates with other hydropower projects to avoid increasing flood flows downstream at a critical time. The timing of flood discharges need to be communicated properly in advance to the local governments and communities. Furthermore, the project developer needs to develop an emergency response plan in the event of extreme floods, upstream dam break, or earthquake. These strategies are essential to ensure the safety of the Xayaburi dam and surrounding local communities.

An example of how climate change has been incorporated into the project design is the Trung Son Hydropower project in Vietnam (2011-2017) financed by the World Bank. Given the difficulty in projecting the changes in extreme events, the Trung Son project opted to mitigate the possibility of a dam failure instead. In addition to adopting a design that is capable to withstand a 1:1,000 year Probable Maximum Flood (as calculated based on the historic river data), the project added a secondary "fuse dam" to the design. In the event of a 1:1,000 year flood, this "fuse dam" would breach, providing a secondary outlet to the reservoir and protecting the main dam.

[67] ADB, 2012.

The project has also established zoning and warning systems in the flood zone to reduce the potential loss caused by a breach. These are adaptation options that can be explored for the Xayaburi project.[68]

Changes in flows

To respond to the changes in flow level and variability, the Xayaburi project can consider a number of capital and operational strategies. For example, the project may increase dam height (to take advantage of the likely increased flow and increase protection against flooding), or modify tunnels to better handle changes in water flows. To address increased sedimentation due to higher runoff, the project can modify spillway capacities to increase flushing of silted reservoirs. Another option is to modify the number and type of turbines that are better suited to the expected water flow rates, more resilient to performance reductions (in case of lower flows in the dry season), and can better withstand higher suspended sediment loads. However, these structural measures can be expensive, especially when they were not incorporated into the project design and are added/ modified after construction has completed. In addition, these measures can have negative environmental and social impacts – increased dam height can further inhibit fish migration and affect the river flow regime for example. It is therefore important to understand the likely future climate conditions, the cost-effectiveness of the structural measures, and their potential environmental and social impacts to determine whether these measures are necessary and desirable.

In addition, there are non-engineering measures that the project can take, such as making operational and maintenance adjustments to adapt to changes in rainfall or river flow patterns. It is important to develop adaptive management operating rules given the uncertainty in precipitation projections, and the production expectations may need to be adjusted to respond to the changes in available supply. The project can also work with local and regional institutions to improve hydrologic forecasting and enhance coordination in power planning and operations.

Finally, the project can collaborate with the local governments and communities to restore and improve management of the upstream land such as afforestation and/or reforestation. Such activities can reduce floods, erosion, and siltation, thus mitigating the impacts of climate change on the project infrastructure.[69] These are no-regret measures that would improve the resilience of the project's infrastructure as well as of the local communities, regardless of the direction and magnitude of changes in climate variables.

Monitoring and Evaluation

Monitoring and evaluation will be critical to establish an ongoing understanding of how climate will impact the Xayaburi hydropower project in Laos. A baseline needs to be established before the construction of the project, and a comprehensive monitoring and evaluation plan should be done on regular intervals, including during the construction and operation phase. The monitoring and evaluation plan should seek to monitor three elements of the project: (1) the overall project success, (2) environmental and social impacts, and (3) climate variables.

The Mekong River Commission's *Preliminary Design Guidance for Proposed Mainstream Dams in the Lower Mekong Basin*[70] provides design guidance in the form of performance targets, design and operating principles for mitigation measures, as well as compliance monitoring and adaptive management to reduce the environmental and social risks posed by the hydropower schemes. Specifically, the document provides guidance on monitoring and evaluation in three main areas, namely fish passage, sediment, and water quality and aquatic ecology.

[68] Independent Evaluation Group (IEG) World Bank/ IFC/ MIGA, 2012.
[69] ADB, 2012.
[70] MRC, 2009b.

The available documents from the project developer and the MRC did not provide a monitoring plan to assess overall project success. However, monitoring and evaluation of environmental and social impacts was addressed. In its *Environmental Impacts Assessment* (2010), Ch. Karnchang outlined a monitoring plan that covered the following areas: surface water hydrology; surface water quality; aquatic ecology, fisheries, and aquaculture; transportation and navigation; public health and nutrition; and aesthetics and tourism. The company indicated that the monitoring of surface water hydrology, surface water quality, and aquatic ecology, fisheries, and aquaculture will be conducted during the construction phase and throughout the operational period which is more than 20 years.[71] Ch. Karnchang's *Social Impacts Assessment* (2010) also provided a brief description of a monitoring plan for resettlement implementation activities.[72] The monitoring plans focused on local impacts in the project area and did not consider any transboundary environmental and social impacts.

In its review published in March 2011, the MRC asserted that Ch. Karnchang's monitoring plans were inadequate and did not fully comply with the *Preliminary Design Guidance*. The MRC stressed the need for an improved monitoring program to fill existing knowledge gaps about the impacts of the project, and provide information to adapt mitigation and management measures to minimize the negative effects. The MRC provided a detailed list of recommendations for monitoring and evaluation in each main area (fish passage, sediment, and water quality and aquatic ecology). Most importantly, the MRC emphasized the need to conduct a *comprehensive baseline assessment* of the fauna, flora, habitat, and socio-economy potentially affected by the project (a socio-economic baseline will measure the Lower Mekong River communities' dependence on fish, other aquatic animals and plants, irrigation and riverbank cultivation, as well as their vulnerability and resilience). Such an assessment is critical to enable effective monitoring of social and environmental impacts. Once the baseline assessment has been completed, a monitoring program needs to be conducted both during the construction and operation period of the project.[73]

In its independent report published in August 2011, Pöyry agreed with the MRC that improvements to the project's monitoring plans and the completion of a *comprehensive baseline assessment* are strongly needed. However, the Finnish engineering company recommended that these can be developed during the early construction phase and not prior to dam construction.[74] The MRC responded by stating that conducting investigations before dam construction will reduce risks and avoid measures that may lead to irreversible unintended consequences. In particular, the collection and analyses of baseline data need to be started at least two years before dam construction begins.[75] Furthermore, construction activities could cause negative impacts to the environment and community in Xayaburi, as detailed in the MRC's earlier review in March 2011.[76]

With regards to monitoring the impacts of climate change on the project, it is important to conduct measurements and keep detailed records of the local temperature and precipitation (primary climate variables). In addition, there is a need to monitor secondary climate variables such as water temperature, water level, and water flow. Both sets of climate variables can have an impact on the project's infrastructure and its capacity to produce electricity (see the Potential Impacts of Climate Change on Project section). The secondary climate variables have already been included in the environmental monitoring program recommended by the MRC, which comprised monitoring of parameters related to hydrology, fisheries, sediment and nutrients, water quality, and aquatic ecosystem health.[77] This provides a good basis for integrating climate change considerations into the project's monitoring program. To understand climate change implications for the project, the Xayburi

[71] Ch. Karnchang Public Company Limited, 2010a.
[72] Ch. Karnchang Public Company Limited, 2010b.
[73] MRC, 2011a.
[74] Poyry, 2011.
[75] MRC, 2011b.
[76] MRC, 2011a.
[77] MRC, 2011a.

hydropower plant should add local temperature and precipitation to its monitoring program. Records of these primary climate variables as well as of secondary climate variables can be compared with the electricity output to assess the connection between climate change and the project's energy production. In addition, the environmental and social impacts need to be monitored and reviewed in the context of changing climatic conditions. There should be periodic review of the livelihoods and conditions of project affected people (both in Laos and other Lower Mekong countries) to see whether climate change may have reduced or exaggerated the project's impacts on them.

Ch. Karnchang is reportedly continuing its construction activities for the Xayaburi hydropower project. While the company stated that it would implement the recommendations made by Pöyry (namely conducting additional investigations to establish a *comprehensive baseline assessment* and improving the monitoring plans during the early phase of construction), it has not released any plan of how the improvements will be made and when they will be completed as of March 2013. In light of climate change and its potential impacts on the project, it would be advisable to incorporate climate change considerations into the project's revised monitoring plan.

Resources

Asian Development Bank (ADB), 2012. Climate Risk and Adaptation in the Electric Power Sector. Available at: http://www.adb.org/sites/default/files/pub/2012/climate-risks-adaptation-power-sector.pdf.

BBC. 2012. Laos Approves Xayaburi 'Mega' Dam on Mekong. November 5, 2012. Available at: http://www.bbc.co.uk/news/world-asia-20203072.

Ch. Karnchang Public Company Limited. 2008. Feasibility Study, Xayaburi Hydroelectric Power Project, Lao PDR. Final Report. Available at: http://www.mrcmekong.org/assets/Consultations/2010-Xayaburi/xayaboury-dam-feasibility-study.pdf.

Ch. Karnchang Public Company Limited. 2010a. Environmental Impact Assessment, Xayaburi Hydroelectric Power Project, Lao PDR. Available at: http://www.mrcmekong.org/assets/Consultations/2010-Xayaburi/Xayaburi-EIA-August-2010.pdf.

Ch. Karnchang Public Company Limited. 2010b. Social Impact Assessment, Xayaburi Hydroelectric Power Project, Lao PDR. Available at: http://www.mrcmekong.org/assets/Consultations/2010-Xayaburi/Xayaburi-SIA-August-2010.pdf.

Chenaphun, Annie. 2012. Laos holds groundbreaking ceremony for contentious Mekong dam. Reuters. November 7, 2012. http://www.reuters.com/article/2012/11/07/us-laos-dam-idUSBRE8A618I20121107.

Chu, T.H., Jirayoot, K., Lacombe, G., Srinetr., V. 2010. Impacts of climate change and development on Mekong flow regime. First assessment – 2009. MRC Technical Paper No. 29. Mekong River Commission, Vientiane, Laos. Available at: http://www.mrcmekong.org/assets/Publications/technical/tech-No29-impact-of-climate-change.pdf.

Deetes, Pianporn, 2012. Thai Villagers File Lawsuit on Xayaburi Dam. August 8, 2012. http://www.internationalrivers.org/blogs/254/thai-villagers-file-lawsuit-on-xayaburi-dam.

Fuller, Thomas. 2012. Laos Breaks Ground for Controversial Mekong Dam. November 7, 2012. http://www.nytimes.com/2012/11/08/world/asia/laos-breaks-ground-for-controversial-mekong-dam.html.

Harrison, G.P., H.W. Whittington, and A.R. Wallace. 2006. Sensitivity of Hydropower Performance to Climate Change. Available at: http://www.see.ed.ac.uk/~gph/publications/IJPES_Draft.pdf.

Herbertson, Kirk. 2012. The Xayaburi Dam: Threatening Food Security in the Mekong. International Rivers. Available at: http://www.internationalrivers.org/files/attached-files/intl_rivers_xayaburi_food_security_report_sept_2012.pdf.

Independent Evaluation Group (IEG) World Bank/ IFC/ MIGA. 2012. Adapting to Climate Change: Assessing the World Bank Group Experience Phase III. Available at: http://ieg.worldbankgroup.org/content/dam/ieg/climate_change3/cc3_full_eval.pdf.

Intergovernmental Panel on Climate Change (IPCC). 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp. Available at: https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf.

International Centre for Environmental Management (ICEM). 2010. Strategic Environmental Assessment of Hydropower on the Mekong Mainstream Final Report. Prepared for the MRC. Available at: http://www.mrcmekong.org/assets/Publications/Consultations/SEA-Hydropower/SEA-Main-Final-Report.pdf.

International Rivers. 2011. The Xayaburi Dam, a Looming Threat to the Mekong River. Available at: http://www.internationalrivers.org/resources/the-xayaburi-dam-2635.

International Rivers. 2012a. Laos Evades Responsibility and Plows Ahead with Xayaburi Dam. November 5, 2012. http://www.internationalrivers.org/resources/laos-evades-responsibility-and-plows-ahead-with-xayaburi-dam-7714.

International Rivers. 2012b. Does the Xayaburi Dam comply with the Mekong River Commission's Preliminary Design Guidelines? Available at: http://www.internationalrivers.org/files/attached-files/does_xayaburi_dam_comply_with_mrc_design_guidelines.pdf.

International Rivers. 2013. Pöyry's Role in the Xayaburi Dam Controversy. Available at: http://www.internationalrivers.org/files/attached-files/factsheet_on_poyry_role_in_xayaburi_dam_feb_2013.pdf.

Lee, Gary and Scurrah, Natalia. 2009. Power and Responsibility: The Mekong River Commission and Lower Mekong mainstream dams. A joint report of the Australian Mekong Resource Centre, University of Sydney and Oxfam Australia. Available at: http://ses.library.usyd.edu.au/handle/2123/7865.

Mekong River Commission (MRC). 2009a. Adaptation to Climate Change in the Countries of the Lower Mekong Basin: Regional Synthesis Report. Available at: http://www.mrcmekong.org/assets/Publications/technical/tech-No24-adaptation-to-climate-change.pdf.

Mekong River Commission (MRC). 2009b. Preliminary Design Guidance for Proposed Mainstream Dams in the Lower Mekong Basin. Available at: http://www.mrcmekong.org/assets/Publications/Consultations/SEA-Hydropower/Preliminary-DG-of-LMB-Mainstream-dams-FinalVersion-Sept09.pdf.

Mekong River Commission (MRC). 2011a. Procedures for Notification, Prior Consultation and Agreement. Proposed Xayaburi Dam Project – Mekong River. Prior Consultation Project Review Report. Available at: http://www.mrcmekong.org/assets/Publications/Reports/PC-Proj-Review-Report-Xaiyaburi-24-3-11.pdf.

Mekong River Commission (MRC). 2011b. Observations and Comments on the Pöyry Report on the Xayaburi Hydropower Project. Available at: http://www.internationalrivers.org/files/attached-files/mrcs_comments_on_poyry_report_nov_2011.pdf.

Mekong River Commission (MRC). 2011c. Xayaburi Hydropower Project Prior Consultation Process. http://www.mrcmekong.org/news-and-events/consultations/xayaburi-hydropower-project-prior-consultation-process.

Mekong River Commission (MRC). 2011d. Impacts of Climate Change and Development on Mekong Flow Regimes First Assessment – 2009. MRC Management Information Booklet Series No. 4. Available at: http://www.mrcmekong.org/assets/Publications/report-management-develop/MRC-IM-No4-impacts-of-climate-change.pdf.

Mekong River Commission (MRC). 2011e. Integrated Water Resources Management-based Basin Development Strategy for the Lower Mekong Basin. Available at: http://www.mrcmekong.org/assets/Publications/strategies-workprog/BDP-Strategic-Plan-2011.pdf.

Mekong River Commission (MRC). 2013a. Vision & Mission. http://www.mrcmekong.org/about-the-mrc/vision-and-mission. Accessed February 5th, 2013.

Mekong River Commission (MRC). 2013b. The 19th Meeting of the MRC Council, January 15th to 17th, 2013. http://www.mrcmekong.org/news-and-events/events/the-19th-meeting-of-the-mekong-river-commission-council.

Mekong River Commission (MRC). 2013c. The Mekong Basin. Physiography. http://www.mrcmekong.org/the-mekong-basin/physiography. Accessed February 4, 2013.

Mekong River Commission (MRC). 2013d. The Mekong Basin. http://www.mrcmekong.org/the-mekong-basin. Accessed February 4, 2013.

Mekong River Commission (MRC). 2013e. The Mekong Basin Climate. http://www.mrcmekong.org/the-mekong-basin/climate. Accessed February 8, 2013.

Mekong River Commission (MRC). 2013f. Climate Change. http://www.mrcmekong.org/topics/climate-change. Accessed Feburary 8, 2013.

Ministry of Planning and Investment of Lao People's Democratic Republic. 2011. The Seventh Five-year National Socio-Economic Development Plan (2011-2015). Available at: http://www.drrgateway.net/sites/default/files/LAO%205Year%20Dev%20pLan%2020112015.pdf.

MRC Development Partners. 2013. Joint Development Partner Statement, the 19th Meeting of the MRC Council, January 17, 2013. Available at: http://www.mrcmekong.org/news-and-events/speeches/joint-development-partner-statement-19th-mrc-council-meeting-17-january-2013

Pöyry. 2011. Compliance Report: Xayaburi Hydroelectric Power Project. Prepared for the Government of Lao PDR. Available at: http://www.poweringprogress.org/download/Reports/2012/July/Compliance%20Report%20Xayaburi%20Main%20Final.pdf.

The Irrawady. 2012. Xayaburi Dam Constructors Defy Moratorium. Available at: http://www.irrawaddy.org/archives/8100. Accessed September 27, 2013.

U.S. Bureau of Reclamation (USBR). 2009. Chapter 11. Flood Overtopping Failures of Dams. Available at: http://www.usbr.gov/ssle/damsafety/Risk/BestPractices/11-FloodOvertopping201108.pdf.

Vandenbrink, Rachel. 2012. Ground Broken on Xayaburi. Radio Free Asia. November 7, 2012. http://www.rfa.org/english/news/laos/xayaburi-11072012163416.html

Vietnam Ministry of Natural Resource and Environment. 2012. Climate Change and Sea Level Rise Scenarios for Vietnam. Available at: http://www.cbcc.org.vn/documents/climate-change-sea-level-rise-scenarios-for-viet-nam.

Viraphonh Viravong. 2013. Statement by H.E. Mr. Viraphonh Viravong, Vice Minister of Energy and Mines of Lao PDR, the 19th Meeting of the MRC Council, January 17, 2013, Available at: http://www.mrcmekong.org/news-and-events/speeches/statement-by-h-e-mr-viraphonh-viravong-19th-meeting-of-the-mrc-council.

World Bank. 2007. Estimating Global Climate Change Impacts on Hydropower Projects: Applications in India, Sri Lanka, and Vietnam. Available at: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2007/09/10/000158349_20070910103932/Rendered/PDF/wps4344.pdf.

World Wildlife Fund (WWF). 2013a. Regional Cooperation on Mekong River in Tatters. http://wwf.panda.org/wwf_news/?207205/Regional-cooperation-on-Mekong-River-in-tatters. Accessed February 4, 2013.

World Wildlife Fund (WWF). 2013b. Discovering the Greater Mekong. http://wwf.panda.org/what_we_do/where_we_work/greatermekong/discovering_the_greater_mekong. Accessed February 4, 2013.

World Wildlife Fund (WWF). 2013c. Hydropower development in the Greater Mekong. http://wwf.panda.org/what_we_do/where_we_work/greatermekong/challenges_in_the_greater_mekong/infrastructure_development_in_the_greater_mekong. Accessed February 27, 2013.

Tata Mundra Coal Power Plant, India

The Tata Mundra Coal Power Plant (Source: Tata Power, 2013).

Table of Contents

List of Figures

List of Tables

Project Background

INTRODUCTION

The Tata Mundra Project is a 4,000-megawatt (MW) coal power plant in the port city of Mundra in India's Gujarat state. The plant was developed by Coastal Gujarat Power Limited (CGPL), a wholly owned subsidiary of Tata Power Company Limited (TPC). The project is comprised of five 800 MW units using supercritical technology, which is more efficient than conventional coal power plants. The power plant is currently fully operational.

The project was designed to provide cheap and reliable electricity to 16 million consumers across the western and northern states of India. An agreement was arranged to import coal from Indonesia to fuel the plant. However, the unforeseen rise in the price of Indonesian coal exports may compromise the project goal.

Figure 1: Project Location

TIMELINE

The main events of the project development to date are provided below.

December 2006: Tata Power Company Limited (TPC) was selected as the developer for the project through a bid process.

2006 – 2007: TPC consultants conducted an environmental impact assessment (EIA), socioeconomic assessment, marine impact assessment, and investigation of impacts on ambient air quality.[1]

April 2007: The Indian Ministry of Environment and Forests (MOEF) provided environmental clearance after reviewing the rapid EIA. A comprehensive EIA was subsequently prepared and submitted, as per the requirement of the environmental clearance.[2]

April 2007: Coastal Gujarat Power Limited (CGPL) executed the project power purchase agreement. Soon after, CGPL became a wholly owned subsidiary of TPC.

September 2010: The Ministry of Energy and Mineral Resources of Indonesia issued a Regulation No.17/2010, requiring mineral and coal producers to sell minerals and coal based on a regulated benchmark price.[3] All contracts were required to be adjusted within 12 months. The new regulation led to a 150 - 200% rise in imported coal prices compared to the start of the bid process. Tata Power has filed a petition before the Central Electricity Regulatory Commission to charge a higher electricity tariff to help offset the higher costs.

June 2011: Various fishing communities filed a complaint against the project with the International Finance Corporation's (IFC's) Office of the Compliance Advisor Ombudsman (CAO).[4] The complaint raises social and

[1] ADB, 2011.
[2] ADB, 2011.
[3] CGPL, 2012.
[4] CAO, 2012.

environmental issues that the fishing communities are facing as a result of the project, including: deterioration of water quality and fish populations, blocked access to fishing and drying sites, forced displacement of fishermen, community health impacts due to air emissions, and destruction of natural habitats, particularly mangroves.

July 2012: The CAO completed the compliance appraisal and found that a number of issues raised merited further investigation.[5] An audit into IFC's role in the project is currently being conducted.

March 2012 – March 2013: All five 800 MW Units were commissioned in March, July, October 2012, January, and March 2013 and are supplying power to the grid.[6]

FUNDING

The total project cost is estimated at about $4.14 billion, which includes $3.147 billion of capital cost.[7] IFC approved a loan of up to $450 million in April 2008.[8] The Asian Development Bank (ADB) proposed a loan of up to $450 million in March 2008, and was approved April 17, 2008.[9]

When first proposed to the IFC, the power plant was expected to sell its electricity generation to utilities in five different states through a 25 year Power Purchase Agreement (PPA). The price terms were competitive, of INR 2.26 per kWh (approximately $0.04 per kWh).[10]

PROJECT LOCATION

The project site is located in Tundawand Village, Taluka Mundra, in Kutch District in the state of Gujarat, India (Figure 1). The entire project area covers a total of 1,054 hectares (ha) of private and public land acquired from the villages of Tundawand (also known as Tunda Wandh), Mota Kandagara, and Nana Bhadiya (Figure 2).[11] Private land was acquired in Tunda, and government land was acquired from Mota Kandagara and Nana Bhadiya.

Economic resources of the area surrounding the project include agriculture, livestock and animal husbandry, and some fishery.[12] The site is located in earthquake zone 5 with risk of high intensity earthquakes.

The project site is 25 km from Mundra port, where imported coal to power the plant is unloaded.[13] Other surrounding transportation networks include State Highways No. SH-50 (Via Anjar) and No. SH-6 (Via Gandhidham) and Adipur railway station. A 100 ha right-of-way through government forestland and private land is required for the coal transport system and 102 ha right-of-way through the Mundra Special Economic Zone for the plant inlet and discharge channels.[14]

---

[5] CAO, 2012.
[6] Tata Power, 2013.
[7] IFC, 2007a.
[8] Ibid.
[9] ADB, 2011.
[10] IFC, 2007a.
[11] CGPL, 2008.
[12] IFC, 2007a.
[13] Ibid.
[14] ADB, 2008.

Figure 2: Project location (CGPL, 2007)

Figure 3: Villages in project affected areas (CGPL, 2008)

PROJECT ASSETS AND OPERATIONS

The Tata Mundra Project consists of **five 800 MW units.** The project is the first supercritical technology based thermal power plant in India. Supercritical technology uses very high temperatures and pressure to turn water directly into vapor, without actually boiling, to operate a turbine and generate electricity.[15] Conventional power plants boil water at a subcritical point to operate the steam turbine and require additional heat to prevent condensation. Supercritical technology is expected to save fuel and reduce greenhouse gas emissions compared to conventional subcritical generating units.

CGPL, who is responsible for the construction, operation, and maintenance of the project and for arranging the required debt finance, is constructing the project through several "packages" or components. A boiler package and a turbine generator package account for approximately 50% of the total project cost.

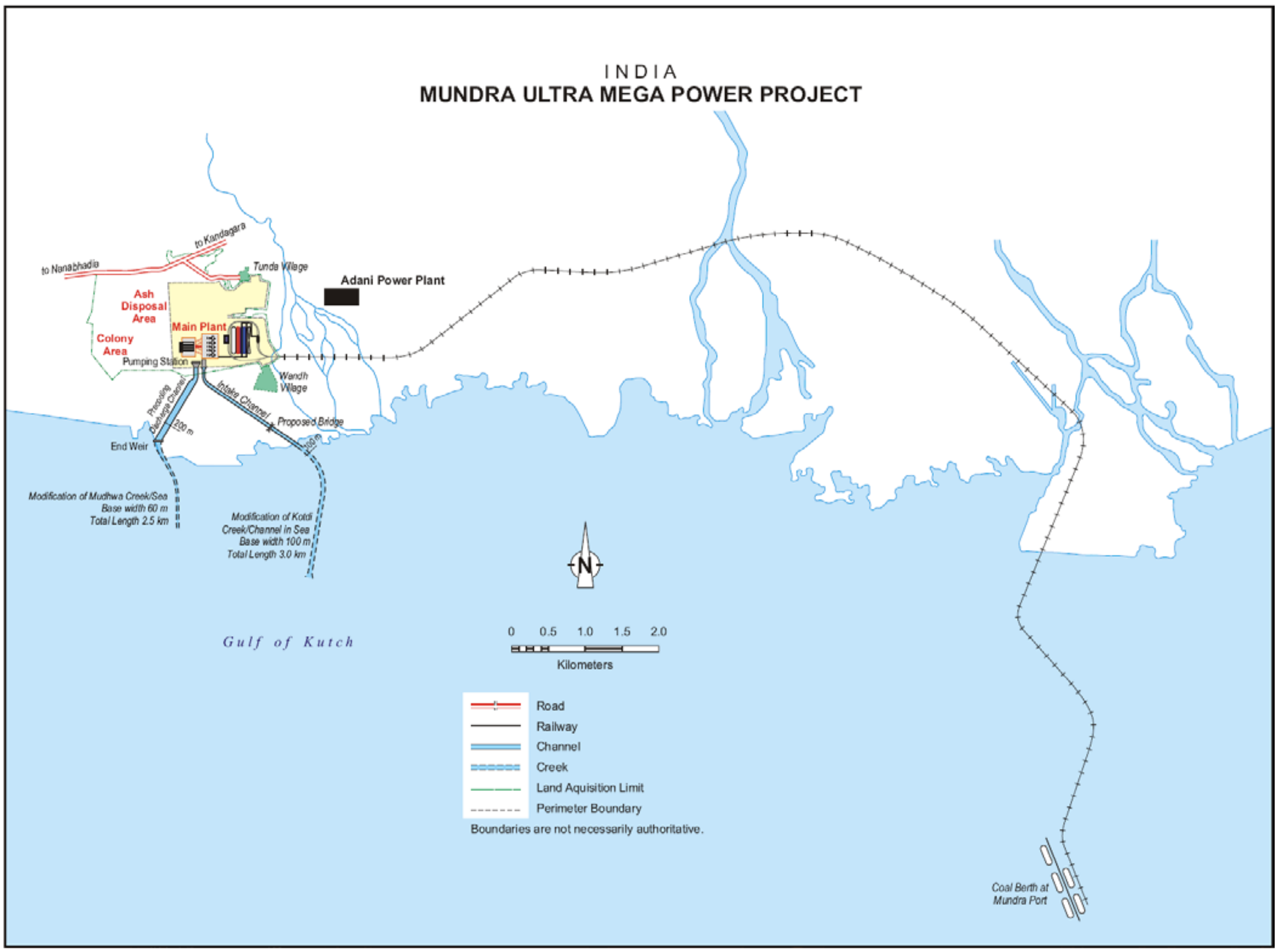
Other infrastructure for this project includes a **water intake and discharge pipeline and a plant to process seawater** to cool the plant's condenser.[16] The project plan includes two open channels to the Gulf of Kutch for intake and discharge of condenser cooling sea water. The intake channel is approximately 6.5 km in length and 100 m in width and is routed through Kotdi Creek. The discharge channel is approximately 4.9 km long and 60 m wide and is routed through Mudhwa Creek. A thermal desalination plant will be installed to supply the coal plant with freshwater.

[15] DOE National Energy Technology Laboratory. http://www.netl.doe.gov/technologies/coalpower/cfpp/technologies/supercritical_utltr_boilers.html
[16] IFC, 2007b.

Up to 11.7 million tons of coal annually is required to power the plant. The power plant was designed to use imported coal from Indonesia. The imported coal was expected to be **unloaded at Mundra port and transported to the project site using a dedicated railway system**. Tata Power originally entered into a long-term fuel supply agreement to import coal from Indonesia at a steep discount to the prevailing market prices. However, due to an Indonesian regulation enacted in 2010, the current price of the imported coal has increased from that specified in the fuel-supply agreement. Tata Power has filed a petition before the Central Electricity Regulatory Commission to charge a higher electricity tariff to help offset the higher costs. Meanwhile, the project is conducting a trial of 70 percent blending of low-calorific value imported coal to reduce the overall cost of fuel.[17]

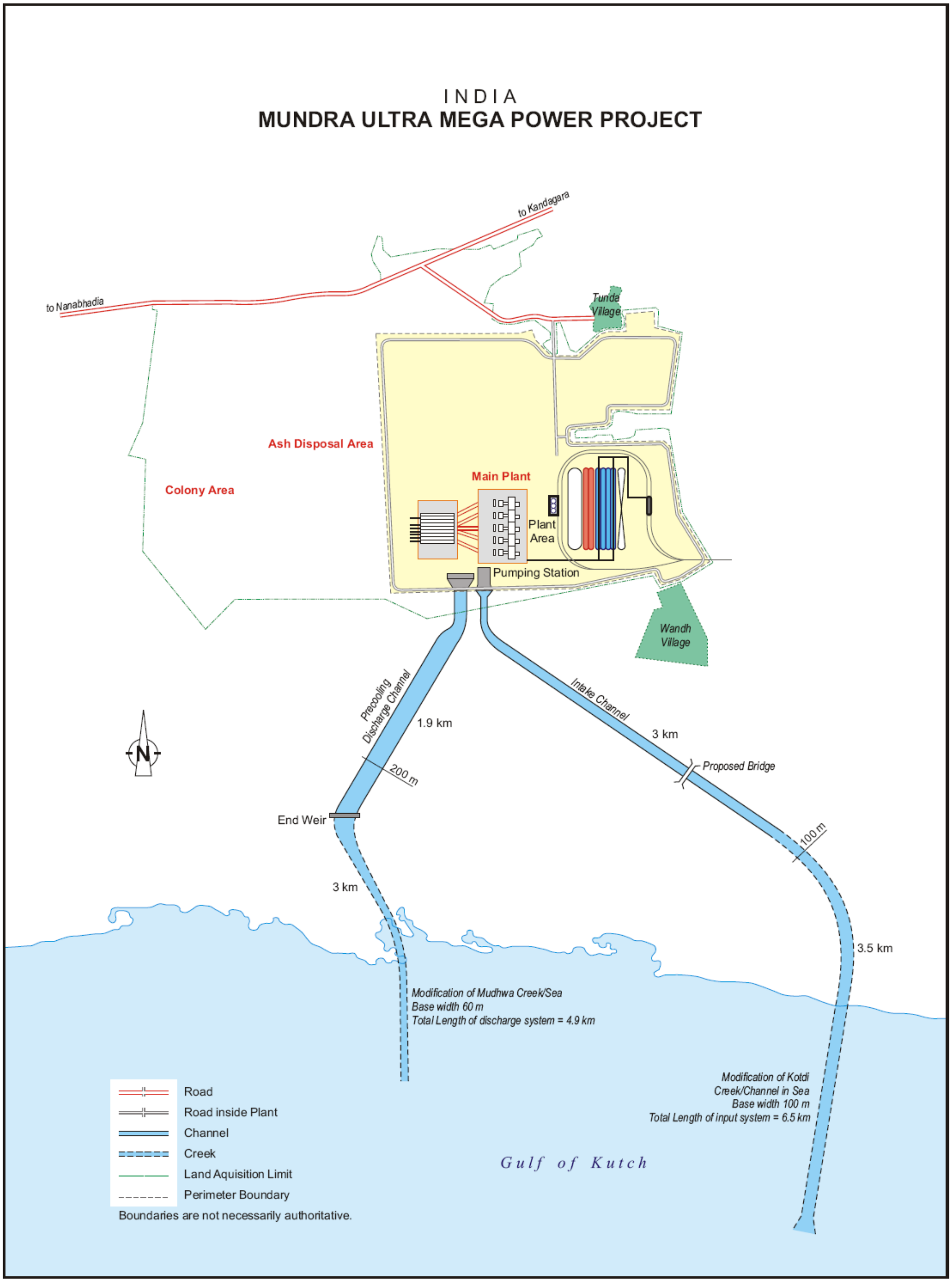
Transmission lines from the power plant were constructed and being operated and maintained by Powergrid Corporation of India Limited (PGCIL). Power is excavated from the plant through three double circuit 400 KV power lines to the states of Gujarat, Maharashtra, Punjab, Haryana, and Rajasthan.

Figure 4: Project site and rail system (CGPL, 2007)



[17] Tata Power, 2013.

Figure 5: Power plant assets (CGPL, 2007)



Environmental and Social Impacts

Environmental Impacts

The project uses supercritical technology, the most energy-efficient coal based power-generation technology available in the country.[18] The project is expected to generate about 764 grams of carbon dioxide per kilowatt hour, emitting 23.8 million tons of carbon dioxide per year. The Indian national average emission factor in 2005 was 1,259 grams per kilowatt hour for coal-based power plants and the average for OECD countries in 2005 was 888 grams per kilowatt hour. A plant using conventional coal power technology and of similar installed capacity is estimated to use 1.7 million tons of additional coal per year and emit a total of 27 million tons of carbon dioxide per year.

The EIA concluded that the emissions from the plant will meet national standards in India and the World Bank's emission guidelines for new power plants.[19] Particulate matter emissions from the plant are expected to be limited to 50 milligram/Normal cubic meter. The ambient air quality is also expected to be within the National Ambient Air Quality Standards (NAAQS) of India.

Construction and maintenance of the intake and outflow channels required dredging and CGPL identified a site for dredge disposal. Additionally, CGPL proposed to maintain the temperature difference between intake and discharge water points below 4° Celsius.[20] The EIA confirms that the discharge of the plant's cooling water will not have significant impacts on the marine environment, or cause coastal erosion and deposition.

Social Impacts

CGPL conducted a household survey and needs assessment study for the project site. The survey was carried out in three villages, encompassing a population of 4,703 people in 1,027 households.[21] Private and public lands were acquired for the project site; 182 ha of private land were acquired in Tunda, displacing 76 families, and 870 ha of government land were acquired from Mota Kandagara and Nana Bhadiya. The public land consisted of 730 ha government wasteland, 130 ha of forest land (open scrub type vegetation), and 12 ha of grazing land. CGPL issued compensation payments for involuntary resettlement to the displaced families on private land. For more information on compensation for resettlement, see the Social Commitments sections below.

The land acquisition impacted the people's livelihoods dependent on grazing land for livestock, wood for charcoal, and land for agriculture. Livestock rearing and milk production are important activities in the affected villages; an estimated 330 households in the affected villages with 9,000 heads of livestock are involved. The cattle herders previously utilized the grazing land, government wasteland, and forest land for grazing and which will be displaced. The Government of Gujarat carried out a survey to provide alternate grazing land. About 100 households in the affected villages also previously utilized the grazing land, forest, and wasteland to find wood to make charcoal a source of livelihood. CGPL acquisition of these lands will limit the locals' access to wood. Furthermore, about 500 people in the affected villages are involved in agricultural labor, and land and opportunities for agriculture were be impacted by the private land acquisition. CGPL designed a Resettlement Plan, detailed in the Social Commitments sections below, to compensate the affected people for loss of land and access to common resources.

In June 2011, fishermen in the vicinity of the project filed a complaint with the CAO against the project. Issues raised included the physical and economic displacement of fishermen from seasonal settlements and fish drying areas in the intertidal zone; impact of coal ash and other airborne pollution on fish drying and public health; and

[18] IFC, 2013.
[19] CGPL, 2007.
[20] CGPL, 2007.
[21] CGPL, 2008.

long-term decline in fish stocks. For more information about impacts on fishermen that were not initially identified, see the Adherence to Social Commitments section below.

Activities during the construction phase resulted in transport of materials, equipment, and temporary in-migration, and may have contributed to pressure on water resources, sanitation, and solid waste management systems. However, the changes to the land, hydrology, and air quality resulting from the project are not expected to exacerbate community exposure to disease.

ENVIRONMENTAL AND SOCIAL COMMITMENTS

Environmental Commitments

The project's **Environmental Management Plan** (EMP) proposes monitoring programs for ambient air quality, surface water quality, ground water quality, noise, and for marine impacts.[22] CGPL established a Corporate Environment and Safety Group to implement the environmental monitoring and evaluation program during both the construction and operation of the plant.

CGPL prepared an **emergency preparedness and response plan** for onsite and offsite emergencies including natural and operational hazards.[23,24] CGPL will communicate the emergency preparedness plan to stakeholders in nearby communities, complete drills, and continually improve the plan. The project is located in an earthquake zone, but the project documents do not specify whether earthquake standards were used during design and construction.

CGPL has made available 130 ha in Bacchau district for afforestation to compensate for the acquisition of forest land.[25] Tata Power is also planting 1,000 hectares of mangroves in the village of Kantiyajal, Hansot, District Bharuch, in compliance with the environmental clearance conditions.[26]

Social Commitments

CGPL conducted a **Social Impact Assessment** (SIA) in the three affected villages and is expected to implement a livelihood restoration program to address impacts of land acquisition. Additionally, a **Resettlement Plan** was developed to address households affected by the land acquisition. A public hearing was held with local officials and residents of villages surrounding the project area to discuss the project's potential environmental and social impacts, land acquisition, mitigation measures, and monitoring programs. Additional public consultations were held as part of the preparation of the comprehensive EIA, land acquisition process, and the SIA. As a result of these meetings, compensation for the 76 families on private land who were displaced was fixed at Rs 1.5 million per ha, a rate higher than Rs 250,000 per ha land acquisition rate fixed by the Government.

The Resettlement Plan also explains the compensation packages for additional parties affected, beyond private landowners.[27] For example, vulnerable affected people who have lost all their agricultural land or are left with unviable parcels will receive assistance in utilizing their compensation to buy alternate land in a nearby area. CGPL is working with the Government of India to provide alternate grazing land, and forestland will be made available to assist the livelihoods of cattle-grazing communities. The livelihood restoration component of the Resettlement Plan includes: (i) training for agricultural laborers on non-land-based activities, (ii) training and material procurement support and market linkages for artisans, (iii) alternate livelihood options and training for

[22] CGPL, 2007.
[23] Ibid.
[24] IFC, 2007b.
[25] Ibid.
[26] IFC, 2013.
[27] ADB, 2008.

charcoal manufacturers, (iv) vocational training for employable persons in technical institutions, (v) implementation of women-led self-help group activities, and (vi) development of grazing and pasture lands.

The Resettlement Plan identified minimal impact of fishing communities because the nearest small fishing community identified located outside the project area, about 2.8 km from the Mudhwa creek. As a result, the Plan does not identify fishermen as project-affected people eligible for compensation packages. However, the project does ensure continued access of the fishing community to fish-drying areas on the coastline with a culvert over the intake channel.

The project created 5,000 construction jobs and 700 operations-oriented jobs.[28] Local labor was used for semi-skilled and unskilled work and migrant laborers are expected during the peak construction period. CGPL is expected to provide appropriate amenities/facilities for labor during construction.

CUMULATIVE IMPACTS

Now complete, the project is providing electricity to approximately 16 million consumers across the western states of Gujarat and Maharashtra and the northern states of Haryana, Punjab, and Rajasthan in India.[29] Many of these states currently face electricity shortages ranging from 7% to 19% and peak power shortages of about 10% to 30%. Reliable power from the project is expected to help improve the competitiveness of the manufacturing and services industries, which often rely on expensive standby diesel generation. Competitively priced power from the project is expected to provide rural and urban areas access to electricity and reduce the subsidy burden on state governments.

The project is located about 2 km from the first-phase development area of the Mundra Special Economic Zone (MSEZ), where Adani Power Limited is constructing a power plant.[30] The cumulative impact assessment focused on the effects of combined emissions from the project power plant and Phase I of the Adani Power Project plant (Phase I: 2 x 330MW = 660 MW). [31] The results show that the combined emissions will be in compliance with the National Ambient Air Quality Standards. As of when the Mundra Environmental Impact Assessment was conducted, Phase II of the Adani Power Project (Phase II: 2 x 330MW+ 2 x 660MW = 1,980MW) was being proposed.

ADHERENCE TO ENVIRONMENTAL AND SOCIAL COMMITMENTS

Environmental Commitments

In compliance with the Environmental and Social Performance Requirements of IFC/ADB, CGPL's consultants submit quarterly and annual Environmental and Social Monitoring Reports during the construction period.[32]

The project's Environmental Management Plan states that imported coal consumption shall not exceed 12 million tons annually and ash and sulfur content in the coal to be used in the project shall not exceed 10 percent and 1 percent respectively. However, the future supply of coal for this project is uncertain due to the rise of import coal prices from Indonesia and the project may have to contract an alternative source for coal supply. Different coal characteristics may have environmental implications in terms of air pollutant emissions, ash generation, and performance of pollution control equipment.

The project is conducting activities to adhere to other environmental commitments, including disposal of fly ash, preparation of a rain water harvesting plan, and monitoring of noise, ground water quality, cool water discharge

[28] Tata Power, 2013.
[29] IFC, 2013.
[30] ADB, 2007.
[31] IFC, 2007b.
[32] SENES Consultants, 2013.

temperature, and ambient air quality. Tata Power has also worked with the Gujarat Ecology Commission to select the location and species of the mangrove afforestation program. As of October 2010, 800 hectares of plantation have been completed in the coastal village of Kantiyajal, Bharuch district.

Social Commitments

In June 2011, various fishing communities filed a complaint against the project with the IFC's Office of the Compliance Advisor Ombudsman (CAO).[33] The complaint raises social and environmental issues the fishing communities are facing as a result of the project, including: deterioration of water quality and fish populations, blocked access to fishing and drying sites, forced displacement of fishermen, community health impacts due to air emissions, and destruction of natural habitats, particularly mangroves. An audit into IFC's role in the project is currently being conducted.

After the complaint was filed with CAO, CGPL initiated measures to improve quality of life of local communities, including fishermen. These measures include improving education, promoting health, building infrastructure, improving access to natural resources, and empowering women.

In the latest annual Environmental and Social Monitoring Report for FY 2011-2012, CGPL's consultants identified social investments that have been carried out.[34] Livestock and agriculture related activities include establishment of milk collection and cattle feed sales centers, drip irrigation demonstrations, and horticulture demonstrations. CGPL has also expanded water supply, financed sanitation facilities, trained teachers at local schools, and formed economic self-help groups for women. CGPL has also addressed community and reproductive health through organization of general health camps and specialized health camps for: vaccinations, eye care, dental, and hemoglobin checkup. The Environmental and Social Monitoring Report does not specify the status of resettlement of displaced households.

Background on Climate Change and Power Plant Projects[35]

A study commissioned by ADB identified climate risks to the electric power sector in the energy supply and power generation phases. Impacts specific to thermal power generation include disruptions to the supply and transport of coal, reduced plant efficiency as a result of warmer temperatures, and the risk of infrastructure damage due to extreme events.

The supply and quality of coal is vulnerable to precipitation events. Coal mine operations require a large volume of water and operations may be constricted with limited water availability. However, excess rainfall and flooding can affect the coal mines themselves or the infrastructure used to transport coal between the mines and power plants. Additionally, excess rainfall can reduce the quality and combustion efficiency of coal stockpiles by increasing the coal's moisture content. The ADB study highlighted the following examples to illustrate how heavy rains have disrupted coal production and transport:

- In late 2010 to early 2011 in Australia, heavy rains and floods caused coal mines to close and buried rail lines in mud. The result was months of reduced production, low coal stocks, and subsequently higher fuel prices for Asian and local buyers.
- In Indonesia, coal production in the Kalimantan region is often slowed during the December through March monsoon season. In late 2010 to early 2012, particularly heavy rains and flooding shut down mines, reduced output, and damaged coal transport.

---

[33] CAO, 2012.
[34] SENE, 2012.
[35] ADB, 2012.

- In July 2010 in the Democratic People's Republic of Korea, heavy rainfall inundated 150 cutting faces of more than 30 coal mines, washed away hundreds of thousands of tons of coal from coal yards, caused pumping equipment failure due to lack of electricity, and caused landslides which damaged bridges and rail lines and delayed transport.

Changes in ambient and water temperature were found to impact power plant operations and assets. A climate change threat and vulnerability assessment was conducted in 2010 for the O Mon IV thermal power plant in Vietnam that was proposed for ADB funding and determined that the components most vulnerable to reduced performance are the gas and steam turbines, the air compressors, and circulating water pumps. The power plant is projected to experience an aggregate loss in power output of approximately 827.5 GW, or 0.8% of total power output, as a result of projected 2.8–3.4°C increases in air temperature and increases in water temperature over the period 2015–2040. Fuel consumption is also expected to increase to account for the reduction in net efficiency. The loss of power output and increased fuel consumption are estimated to cost approximately $11.0 million over the period 2015–2040. Although these numbers are relatively small, analysis conducted on other thermal plants in the region could yield different, and potentially higher, results. Generally, increased water temperature is likely to reduce generation efficiency of plants because power plants use cool freshwater for fuel processing, cooling, and power production purposes. Similarly, an increase in ambient temperature may reduce a thermal power plant's efficiency. The rise in temperature leads to a decrease in the difference between ambient and combustion temperature, reducing the efficiency of generators, boilers, and turbines.

Lastly, extreme events may damage power plants' infrastructure. Higher wind speeds associated with more intense extreme events may damage power plants' infrastructure and greater winds will also cause wider air pollution dispersion. Sea level rise and stronger storm surges may also damage the infrastructure of power plants along the coast.

The extent to which climate change will impact electricity demand will depend on factors including the degree of warming and the growth in populations and buildings.

Local Conditions

CURRENT LOCAL CLIMATE

Gujarat is among the driest regions in India. Ahmedabad, the capital city, is located on the banks of the Sabarmati River, which often dries in summer. The city experiences climate extremes, with notably high temperatures in summer and very low temperatures in winter. Table 1 provides temperature and precipitation data for the period 1971-1990, before significant anthropogenic climate change was observed.[36] During this time, the average monthly maximum temperature in Ahmedabad reached 41.5°C in May. The lowest average monthly mean temperature in winter was 20.1°C in January (ranging from a minimum of 11.8°C to a maximum of 28.3°C). Most rainfall occurred in summer, averaging 247.0 mm in July and 288.0 mm in August.

[36] Hong Kong Observatory, 2012. http://www.weather.gov.hk/wxinfo/climat/world/eng/asia/india/ahmedabad_e.htm

Table 1: Historical Climatological Data for Ahmedabad (1971-1990)

Climatological Information for Ahmedabad, India

Location of weather station : 23.1 N, 72.6 E, altitude : 55 m

	Data Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Maximum Temperature (deg. C)	1971-1990	28.3	30.4	35.6	39.8	41.5	38.4	33.4	31.8	34.0	35.8	32.8	29.3
Mean Temperature (deg. C)	1971-1990	20.1	22.2	27.3	31.7	33.9	32.8	29.5	28.2	29.1	28.5	24.7	21.3
Mean Minimum Temperature (deg. C)	1971-1990	11.8	13.9	18.9	23.7	26.2	27.2	25.6	24.6	24.2	21.1	16.6	13.2
Rainfall Amount (mm)	1971-1990	2.0	1.0	0.0	3.0	20.0	103.0	247.0	288.0	83.0	23.0	14.0	5.0
Days with Rain*	1971-1990	0.3	0.3	0.1	0.3	0.9	4.8	13.6	15.0	5.8	1.1	1.1	0.3
Mean Daily Sunshine Duration (hours)	1971-1990	9.3	9.8	9.0	9.9	10.6	7.9	4.2	3.6	7.4	9.4	9.1	9.3

* denotes number of days with at least 1.0 mm of rainfall

Similar data are not available for the port city of Mundra, where the Tata Mundra plant is located. However, the climate of India's coastal plains is generally wetter and milder than observed in inland areas such as Ahmedabad, with relatively constant temperatures in winter and hot and humid weather in summer.[37]

CLIMATE CHANGE PROJECTIONS

Projected Temperature and Precipitation[38]

The most recent climate change projections for India were made for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) using the newly developed representative concentration pathways (RCPs) scenarios under the Coupled Model Inter-comparison Project 5 (CMIP5). Under the RCP "business-as-usual" scenario, model results indicated that mean warming in India is likely to be in the range 1.7–2°C by the 2030s and 3.3–4.8°C by the 2080s relative to the preindustrial period (1880's). All-India precipitation under the business-as-usual scenario is projected to increase from 4 to 5% by 2030s and from 6 to 14% by the 2080s compared to the 1961–1990 baseline. Long-term precipitation projections were generally more robust than their short-term counterparts, although precipitation projections, in general, are less reliable than temperature projections. The analysis also found a consistent positive trend in frequency of extreme precipitation days (e.g. > 40 mm/day) for the 2060s and beyond.

Sea Level Rise

The Tata Mundra Project draws cooling water from the Gulf of Kutch. This area is highly vulnerable to increases in storm surges and inundation as a result of climate change. The Government of India estimated that sea level rise between 3.5 to 34.6 inches between 1990 and 2100 would result in significant salinization of India's coastal lands and groundwater, with the Gulf of Kutch one of the most vulnerable stretches along India's western coast.[39] The combination of sea level rise and ocean warming is expected to increase storm surges from more frequent and intense tropical cyclones in coastal areas.[40] Although data for Mundra are not available, a recent study projected inundation of 43% of the coastal area near Jamnagar, across the Gulf of Kutch from Mundra,

[37] Government of India, 2012.
[38] Chaturvedi et al., 2012.
[39] Government of India, 2012.
[40] IPCC, 2012.

assuming a current 1-in-100-year storm surge, increasing by 13% over the next 100 years given a 10% increase in storm surge as a result of climate change.[41]

Potential Impacts of Climate Change on Project

PROJECT INFRASTRUCTURE AND OPERATIONS

Precipitation and Flooding

Precipitation is projected to increase based on country-wide data, and may affect the supply of coal, coal transportation network, and power plant infrastructure. The supply and quality of coal from Indonesia may be affected by precipitation levels. Greater precipitation could result in flooding of mines as well as increase the coal's moisture content. Currently, coal production in a region in Indonesia is often slowed during the monsoon season due to heavy rains and flooding.

Extreme events may also affect the transportation network used to transport the imported coal from the port to the plant site. Flooding, water logging, and erosion may cause structural damage to rail lines and service disruptions. Storms and high winds associated with extreme events will also result in structural damage to transportation infrastructure and require increased maintenance.

Higher wind speeds from more intense extreme events may damage the plant's infrastructure and disperse air pollutants to a wider range of communities. If incidents of flooding become more frequent and/or severe, the power plant may be damaged from inundation.

Increased Temperatures

Increased water temperatures in the Gulf of Kutch will reduce the generation efficiency of the power plant. Ambient air temperatures are also projected to increase, and may reduce the plant's efficiency because more energy will be required for combustion.

Sea Level Rise

Sea level is projected to rise in the Gulf of Kutch and will impact navigability in ports and storage and transfer facilities in ports, creating challenges for unloading imported coal at Mundra Port. Encroaching salinization along the coast may add stress to the power plant's desalinization plant. Associated storm surges will also contribute to land erosion, flooding and water logging, resulting in increased maintenance, structural damage, and service disruptions of the transportation infrastructure.

Adaptation Options[42]

Precipitation and Flooding

Mines can adapt to changes in precipitation and flooding by building or enlarging reserves to reduce flooding risk and reduce water shortages. However, since these adaptation options are the responsibility of coal extractors, CGPL must explore other adaptation options to ensure the coal supply and quality from the demand side. For example, the project may protect coal stockpiles through storage infrastructure.

[41] Dasgupta et al., 2009.
[42] ADB, 2012.

Close monitoring of precipitation impacts on the project assets may protect the infrastructure from damage. Afforestation of the surrounding land may reduce flooding. If flooding were to become more frequent or severe, it may be necessary to upgrade project assets to protect them from damage.

Increased Temperature

The project should monitor the degree to which higher ambient air and water temperatures will reduce the plant's efficiency, to determine the need to implement adaptation options. Pretreatment of the intake air to reduce temperature or redesign of the topping cycle technology may improve the performance of the gas turbine cycle. Additionally, reducing the intake water temperature or increasing the performance of the cooling water system pumps and heat exchangers may improve the performance of the cooling water cycle.

Sea Level Rise

CGPL has already planted mangroves along the coast, which may serve as a natural buffer for storm surges. Additional adaptation options, if needed, include developing flood control structures, raising the level of structures, and improving drainage pipes.

Monitoring and Evaluation

Monitoring and evaluation will be critical to establish an ongoing understanding of how climate will impact the Tata Mundra Project in India. A comprehensive monitoring and evaluation plan should be done on regular intervals, during and beyond the construction phase of the project, and seek to monitor three elements of the project: (1) the overall project success, (2) environmental and social impacts, and (3) climate variables.

What to Monitor

The March 2008 ADB Report and Recommendation of the President to the Board of Directors includes specifics about the monitoring requirement and a design and monitoring framework. Table 2 is an augmented version of the Design and Monitoring Framework that was provided by ADB. Fields in red under the "Climate-Related Monitoring" are suggestions of how the project may supplement their monitoring framework to address climate change considerations.

Table 2: Design and Monitoring Framework[43]

Design Summary	Performance Targets/Indicator	Data Sources/Reporting Mechanisms	Assumptions and Risks	Climate-Related Monitoring
Impact Promoting economic growth and development and contributing to India's Power for All by 2012 goal through the enhanced supply of efficient, reliable, and clean power	Peak shortages and energy outages reduced by 50% by 2012 and 75% by 2017 At least 5 ultra mega power plants based on supercritical technology in operation by 2015	National electricity statistics National macroeconomic data Reports by the central and states' power subsector regulators	**Assumption:** Continued macroeconomic and political stability Continued implementation of power subsector reforms	Keep records of the local climate and periodically review these in comparison to the electricity shortage and outage trends.
Outcome Operating efficiency in coal-based generation increased Induction of clean coal technology in India Supply of competitively priced electricity leading to development of an efficient electricity market Mitigation of greenhouse gas emissions	Project achieves gross efficiency of 44% compared with baseline of 34%–36% Project demonstrates viability of supercritical technology operating at over 90% availability Peak and energy shortages reduced by 50% in five states by 2013 Power requirements under the power purchase agreements met Project generates about 28 million tons of carbon dioxide savings over 10 years of operation	CGPL's operating reports Financial records of the procurers National and state electricity statistics Registration of the Project by the CDM executive board	**Assumption:** Timely completion of the transmission line Financial position of the offtakers remains stable and improves with implementation of reforms Revenue from CDM post-2012 depends on the agreement of a post-Kyoto protocol for climate change	Keep records of the local climate and periodically review these in comparison to the power plant's generation and efficiency.

[43] ADB, 2008.

Outputs Increased electricity generation capacity Use of more efficient coal technologies	Five units of 800 MW each commissioned and all units operating by July 2012 First coal plant based on supercritical technology operating in India	Project company's operating reports	**Assumption:** No delay in the procurement and supply of boilers and turbines; engineering, procurement, and construction; and civil works Finances are raised Mitigation measures for adverse environmental impacts are in place **Risk:** Project delay may result without adequate construction management given that the Project has multiple contracts	Periodically review the local climate and how it may have impact the construction and operation of the plant.

Activities with Milestones	**Inputs**
1. Notice to proceed issued on 1 September 2007 2. Environmental and social requirements complied with prior to construction on site 3. Completion of construction and COD for unit 1 (800 MW): 1 March 2011 4. Completion of construction and COD for unit 2 (800 MW): 1 July 2011 5. Completion of construction and COD for unit 3 (800 MW): 1 November 2011 6. Completion of construction and COD for unit 4 (800 MW): 1 March 2012 7. Completion of construction and COD for unit 5 (800 MW): 1 July 2012	<u>Equity</u> TPC: $1.057 billion <u>Debt</u> Asian Development Bank: (i) Direct exposure: $250 million (ii) KEXIM risk participation: $200 million Other sources: $2.720 billion

ADB = Asian Development Bank, CDM = clean development mechanism, COD = commercial operation date, KEXIM = The Export-Import Bank of Korea, MW = megawatt, TPC = The Tata Power Company Limited.

Table 3: Development Effectiveness Framework[44]

Objective	Impact	Performance Targets	Measurement	Climate-Related Monitoring
Private Sector Development	**Project Company Impact** Brings technical and operating skills Implements state-of-the-art technology for power generation Implements global standards for environment, health, and safety; and possible revenue generation from sale of GHG emissions reduction	Access to and successful operation of improved technology Profitable business and better environmental management and mitigation of GHGs	The project company's operating, financial, and environmental performance	Periodically analyze the local climate data in relation to the project's operational and financial performance. Consider how changes in climate may have contributed to the project's environmental performance.
	Beyond Company Impact Prepares for more private sector participation and financing Provides competitive pressure on other players to increase the industry's efficiency Induces innovation and penetration of improved technologies Promotes market-based power subsector, which induces private investment Demonstrates effectiveness of regulatory environment and private sector participation in the economy Generates employment	Follow-on privatization of other power plants financed by long-term private sector finance Competitive tariff Increased electricity supply to fuel economic growth and raise standards of living Creation of employment and livelihood opportunities	Increase in percentage of power generating capacity in the private sector Development and operation of other supercritical power plants in the country GDP growth and household income growth	Review the local climate data in relation to the electricity supply. Consider how climate can affect the variability of the supply and how that would impact economic growth and livelihood in the long-term.

[44] ADB, 2008.

Business Success	Financially profitable Sustainable operations	Financial internal rate of return greater than weighted average cost of capital Timely and self-sustaining debt service	Financial ratios Operations reports	Periodically review the local climate data in relation to the project's finances and operations. Consider if extreme climate events have hampered the project's profitability and/or operations.
Economic Sustainability	Contributes to economic growth, improvement to the environment, and improvement of living standards through the mitigation of power shortages	Economic internal rate of return greater than 12% Increase in per capita electricity consumption Reduction in GHG emissions	Economic internal rate of return Electricity sales	Periodically review the local climate data in relation to the project's finances.

When to Monitor

To adequately monitor and evaluate the program, it should be done on regular intervals. Currently the monitoring program requires CGPL to carry out Environment Health Safety and Social (EHSS) compliance audits on a quarterly and annual basis during the construction period.[45] The purpose of the reports is to monitor CGPL's compliance with the Environmental and Social Performance Requirements of IFC/ADB, including implementation of the Environmental Management Plan and the Social Management Plan.

Intervals

The monitoring interval should be contingent on what element of the project is monitored. Annual or even periodic (every five years) monitoring and evaluation may be a sufficiently frequent to determine the overall project success in meeting the increased power demand and addressing social impacts of the project. However, environmental and climate variables may need to be monitored on a more frequent basis. Environmental impacts may be more prevalent during certain seasons; annual assessments of the environment may not reveal critical impacts that occur during only one part of the year. Similarly, to understand the impact of climate variables on the project, regular monitoring with periodic evaluation would be prudent.

Duration

Currently the project and ADB only require monitoring for environmental and social impacts during construction of the project. However, the power plant is expected to operate for several decades after the implementation phase is complete. Additionally, since climate projections are always made with a degree of uncertainty and the impacts are likely to be observed over a long period of time (decades, not months), monitoring and evaluation of the impact of climate change on the project should be established and continue for the duration of operation.

[45] SENES Consultants, 2013.

To understand the real threat and potential impact of shifts in precipitation and flooding, temperatures, and sea level, local data should be collected on a regular interval. Historical temperature and precipitation data for the city of Mundra is not available. Local daily measurements would provide an accurate and clear understanding of the climatic conditions on the Tata Mundra Project.

In addition to monitoring the local climatic conditions, it would be prudent to implement regular monitoring of the project assets – including the power plant facilities and the auxiliary infrastructure. Regular monitoring of these assets, in conjunction with the climate data would provide a valuable baseline from which to evaluate the operational status for the project.

Resources

ADB. 2007. India: Mundra Ultra Mega Power Project. Environmental Assessment Report. http://www.adb.org/sites/default/files/projdocs/2007/41946-IND-SEIA.pdf

ADB. 2008. Proposed Loan - India: Mundra Ultra Mega Power Project. Report and Recommendation of the President to the Board of Directors. http://www.adb.org/sites/default/files/projdocs/2008/41946-IND-RRP.pdf

ADB. 2011. Mundra Ultra Mega Power Project Data Sheet. http://www.adb.org/projects/41946-014/details

ADB. 2012. Climate Risk and Adaptation in the Electric Power Sector. http://www.adb.org/publications/climate-risk-and-adaptation-electric-power-sector

CAO. 2012. Appraisal Report. http://www.cao-ombudsman.org/documents/AppraisalReport_IndiaTataUltraMega_July2012.pdf

CGPL. 2007. Comprehensive Environmental Impact Assessment Study Report. http://www.ifc.org/ifcext/spiwebsite1.nsf/0/ECC4CB9DA96C0888852576BA000E2C79/$File/Comprehensive%20EIA-CGPL%20Vol1.pdf

CGPL. 2008. Household Survey and Needs Assessment Study. http://www.ifc.org/ifcext/spiwebsite1.nsf/0/ECC4CB9DA96C0888852576BA000E2C79/$File/Household%20Survey%20and%20Needs%20Assessment%20Study.pdf

CGPL. 2012. Tata Power Mundra Ultra Mega Power Project: Towards a cleaner and greener future. http://www.tatapower.com/cgpl-mundra/pdf/umpp-greener-future121015.pdf

Chaturvedi, R.K., J. Joshi, M. Jayaraman, G. Bala, and N.H. Ravindranath. 2012. Multi-model climate change projections for India under representative concentration pathways. Current Science 103:791-802.

Dasgupta, S. et al. 2009. Climate Change and the Future Impacts of Storm-Surge Disasters in Developing Countries. Working Paper 182, Center for Global Development, Washington, D.C. http://www.cgdev.org/content/publications/detail/1422836.

Government of India. 2012. India, Second National Communication to the United Nations Convention on Climate Change. Ministry of Environment and Forests, Government of India.

IFC. 2007a. Tata Ultra Mundra: Summary of Proposed Investment. http://www.ifc.org/ifcext/spiwebsite1.nsf/ProjectDisplay/SPI_DP25797

IFC. 2007b. Tata Ultra Mundra: Environmental & Social Review Summary. http://www.ifc.org/ifcext/spiwebsite1.nsf/ProjectDisplay/ESRS25797

IFC. 2013. Frequently Asked Questions: Tata Mundra Project. http://www1.ifc.org/wps/wcm/connect/region__ext_content/regions/south+asia/countries/frequently+asked+questions

IPCC (Intergovernmental Panel on Climate Change). 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change and Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. World Meteorological Organization, Geneva, Switzerland.

SENES Consultants India Pvt Ltd. 2013. Annual Environment & Social Performance Report – Tata Ultra Mega Coal Fired Power Plant, Mundra, Period: April 2011 to March 2012. http://www.adb.org/sites/default/files/projdocs/2013/41946-014-ind-semr.pdf

Tata Power. 2013. 4000 MW Mundra Ultra Mega Power Project (UMPP). http://www.tatapower.com/cgpl-mundra/home.aspx

Dawei Seaport and Industrial Zone, Burma

The Loading Platform of the Small Port in Dawei (Source: ITD, 2013e).

Table of Contents

List of Figures

Project Background

INTRODUCTION

Italian-Thai Development (ITD) Public Company Limited, Thailand's largest construction firm, is developing a deep seaport and industrial zone in Dawei, Burma (Myanmar) (Figure 1). The project will include construction of a deep seaport, connecting road and rail links to Thailand, oil and gas pipelines along those links, an industrial complex, as well as residential and commercial housing and other supporting infrastructure.[1] If completed, it will become a major industrial, trade, and logistics hub in the region. The New York Times called Dawei "an industrial project that could change Burma".[2] It is expected to bring much needed infrastructure to Burma and boost the country's economic growth after decades of stagnation. However, it can also cause significant negative impacts on the local population and environment. There are also concerns with the project's financial viability due to the magnitude of investments required. As a result, whether the completion date and scale of the project, as well as its benefits and consequences, will be realized remain to be seen.

Figure 1: Project Location

TIMELINE

The ITD started the Dawei project during a time of rapid political and economic changes in Burma. A chronology of the Dawei project development alongside recent changes in Burma's political economy is presented below. It shows that the Thai government and ITD signed the Memorandum of Understanding with the military government of Burma just five days before the first election in Burma in two decades, without knowing the potential result and political changes that can follow. Since then, the new government (led by President Thein Sein) has enacted Burma's first-ever environmental law and drafted a new Special Economic Zone law that would replace the one put in place by the former military government. The Thai government and ITD are thus taking significant political risks in undertaking the Dawei project and face high legal uncertainties as the new government in Burma rolls out its reforms. Nonetheless, they are moving forward due to the expected high economic returns from the project.[3] ITD plans to complete the basic infrastructure, including the deep seaport, road link, rail link, water supply and waste water, electricity, telecommunication, and industrial estate at Dawei by 2015.[4] The weak land, environmental, and health rules and regulations in Burma also raise concerns about the potential impacts of the project on the local communities and environment.[5] A brief project timeline follows.

May 19, 2008: The military government of Burma and the government of Thailand signed a Memorandum of Understanding to develop a deep seaport in Dawei and a road link between Dawei and Bangkok.[6]

[1] ITD, 2013a.
[2] The New York Times, 2010.
[3] Thabchumpon et al., 2012.
[4] ITD, 2013a
[5] Thabchumpon et al., 2012.
[6] ITD, 2013b.

November 2, 2010: ITD signed a Framework Agreement with Burma's Port Authority, which granted ITD the rights to develop and operate the Dawei project over a 75-year land lease period and a 60-year concession period with possible extension. The Agreement expanded the scope of the project to include a special economic zone (industrial estate), rail link, and township for residential and commercial development.[7] According to the Agreement, ITD will pay US $37.5 million for the land lease concession of 250 square kilometers. The first installment of US $1 million was paid in December 2010 and the rest will be paid by installment after establishment of the Dawei Special Economic Zone.[8]

November 7, 2010: Burma held the first election in two decades. The military-founded Union Solidarity and Development Party won a landslide victory as expected. Five days later, Nobel Peace Prize laureate Aung San Suu Kyi was released from her extended house arrest.[9]

January 27, 2011: The military government of Burma enacted the Burma Special Economic Zone Law and Dawei Special Economic Zone Law, which provides protection and investment privileges including tax exemption to the Dawei project.[10] The laws were enacted two months before the military government stepped down.

March 30, 2011: Burma ended the military rule with the smooth transfer of power to an elected civilian government led by President Thein Sein. The new government started implementing democratic reforms in the fall of 2011.[11]

August 19, 2011: A historic meeting took place between President Thein Sein and Aung San Suu Kyi. The new government started to cooperate with Aung San Suu Kyi and amended the electoral law, paving the way for her party, the National League for Democracy, to re-register as an official party.[12]

September 16, 2011: ITD established a subsidiary company, Dawei Development Company Limited, in Burma to implement the Dawei Project.[13]

November 14, 2011: Italian-Thai Development signed a Memorandum of Understanding with Ratchaburi Electricity Generating Holding Public Company Limited (RATCH) to jointly conduct a feasibility study of a 4,000 megawatt coal-fired power plant at Dawei. This plant will supply the electricity for business operation at Dawei as well as for export to Thailand.[14]

December 15, 2011: A local group, Dawei Development Association, protested against the construction of the 4,000 megawatt coal-fired power plant.[15]

January 9, 2012: The Burma government decided to reject the proposed 4,000 megawatt coal-fired power plant at Dawei due to environmental concerns. However, the government was still considering whether to continue with a smaller plant to support the project.[16] On August 1, 2013, ITD reported that a power plan with a capacity of 600 MW is to be completed by 2017.[17]

[7] ITD, 2013b.
[8] ITD, 2012.
[9] Thabchumpon et al., 2012.
[10] ITD, 2013c.
[11] Thabchumpon et al., 2012.
[12] Thabchumpon et al., 2012.
[13] ITD, 2013b.
[14] ITD, 2011.
[15] Thabchumpon et al., 2012.
[16] Thabchumpon et al., 2012.
[17] ITD, 2013d.

March 2012: The parliament of Burma enacted the country's first-ever environmental law, which requires development projects to conduct Environmental Impact Assessment and Social Impact Assessment. The new government also approved a new foreign investment law. It stated that a new Special Economic Zone law was being drafted and will replace the Special Economic Zone law enacted by the former military government.[18]

June 25, 2012: The Thailand Ministry of Finance authorized a working group to provide financial support for the development of the Dawei project.[19]

August-November 2012: Since the Thai and Burma governments agreed on July 23, 2012 to connect Dawei to the Thai port of Laem Chabang, 100 kilometers southeast of Bangkok, Thai banks led by Bangkok Bank and Siam Commercial Bank arranged a US $325 million bridge loan to sustain the Dawei project for another 8-10 months.[20]

February 12, 2013: The Thai Office of Transport and Traffic Policy and Planning decided to review the estimated investment needed for the Dawei project due to differences in key project information provided by the Burma government and ITD. The discrepancy could affect the calculations of the rate of return and the project's feasibility.[21]

May 2013: In its 2012 Annual Report, ITD indicated that it was increasing the speed of construction of roads, infrastructure, and port works to attract investors. As of May 2013, ITD has completed the main road in Dawei Special Economic Zone, the 150 km access road between Dawei and Phu Nam Ron on the border of Burma and Thailand, and the small port. Construction of the dam and reservoir is well underway and ITD has started building the deep seaport. ITD stated that it has completed compensation and relocation survey but compensation payments are still ongoing. Local contractors have partially completed the first phase construction of relocating housing.[22]

June 18, 2013: The governments of Thailand and Burma signed an agreement to create a joint venture for the Dawei project. Thailand and Burma will each take a 50% stake. The joint venture will require **US $1.4 billion** during the first five years (2014-2018). Thailand and Burma hope that the joint venture will attract additional investors from Japan and other countries.[23]

End of 2013: Targeted date to complete the small port and commence operation of the early industrial estate.[24]

End of 2015: Targeted date to complete the first phase of construction (basic infrastructure projects including the deep seaport).[25]

End of 2020: Targeted date to complete all construction.[26]

FUNDING

Italian-Thai Development (ITD) is seeking funding from the Thai government, Thai banks, and other foreign investors, especially Japan. Progress has slowed because of the lack of funds. The Thai government intervened

[18] Thabchumpon et al., 2012.
[19] ITD, 2013b.
[20] Deed, 2012.
[21] Maipanich, 2013.
[22] ITD, 2012; ITD, 2013a; ITD, 2013e.
[23] National News Bureau of Thailand, 2013.
[24] ITD, 2013a.
[25] ITD, 2013a.
[26] Thabchumpon et al., 2012.

to assist ITD in mobilizing the necessary funds. The entire project is projected to cost **US $58 billion** or more; the basic infrastructure projects at Dawei are estimated to cost **US $8.6 billion**.[27]

Thai banks, including state-run banks, have provided US $4 billion for construction at Dawei. In 2012 several Thai Banks arranged a US $325million bridge loan to sustain the project (see Timeline). Development Bank (ADB) has not expressed any interest in investing in the Dawei project due to "concerns about how [the] project should move forward".[28] Private funds are likely to be necessary to complete the project. The Prime Minister of Thailand has urged Japan's Prime Minister to support the Dawei project on two separate occasions in 2013. However, as of August 2013, Japan has not indicated any intention to invest. The project's financial prospect remains highly uncertain as a result.[29]

PROJECT LOCATION

The project is located in Dawei district in Thanintharyi Division, Burma's southernmost region. Thanintharyi Division borders the Andanam Sea to the west and the Tenasserim hills to the east, beyond which is Thailand's Kanchanaburi province. It is adjacent to the estuary of a major waterway, the Dawei River, which is surrounded by the Tenasserim Hills and monsoon forests.

Strategic Location. Dawei offers direct access to the Indian Ocean and can provide a shortcut between Europe and mainland Southeast Asia. It is designed to be one end of a land bridge connecting the Indian Ocean to the South China Sea. The route will connect India, Europe, Africa, and the Middle East with Southeast Asian and East Asian countries. Once completed, the Dawei seaport and its road and rail links will replace the longer and increasingly congested sea route through the Malacca Strait, significantly reducing transportation time and costs (Figure 2). A study estimated that cargo ships could save about 1,250 nautical miles and four days of travel time compared to transiting through the Malacca Strait. [30] Trade between the Dawei port and Bangkok could be conducted within a day via a 300 km road corridor. The Dawei port will be connected to Bangkok via Kanchanaburi through the construction of two highway segments, and eventually to seaports in Vietnam through the Greater Mekong Subregion Southern Corridor (Figure 3).

Due to its location, the Dawei project is of strategic interest to Thailand and is therefore receiving tremendous support from the Thai government. Dawei is Bangkok's nearest gateway to the Andaman Sea, and ultimately to India, Europe, Africa, and the Middle East. It also fits into a greater regional development plan sponsored by the Asian Development Bank (ADB), including the East-West Economic Corridor, a massive transport and trade network connecting Burma, Thailand, Laos and Vietnam; the Southern Economic Corridor connecting Thailand with Cambodia and Vietnam; and the North-South Economic Corridor with rail links to Kunming, China.[31]

[27] Chachavalpongpun, 2011.
[28] Bloomberg, 2012.
[29] The Economist, 2013.
[30] Thakhin, 2011.
[31] Paung Ku and Transnational Institute, 2012.

Figure 2. The Dawei Port will connect India, Europe, Africa, and the Middle East with East Asia, replacing the longer sea route through the Malacca Strait.[32]

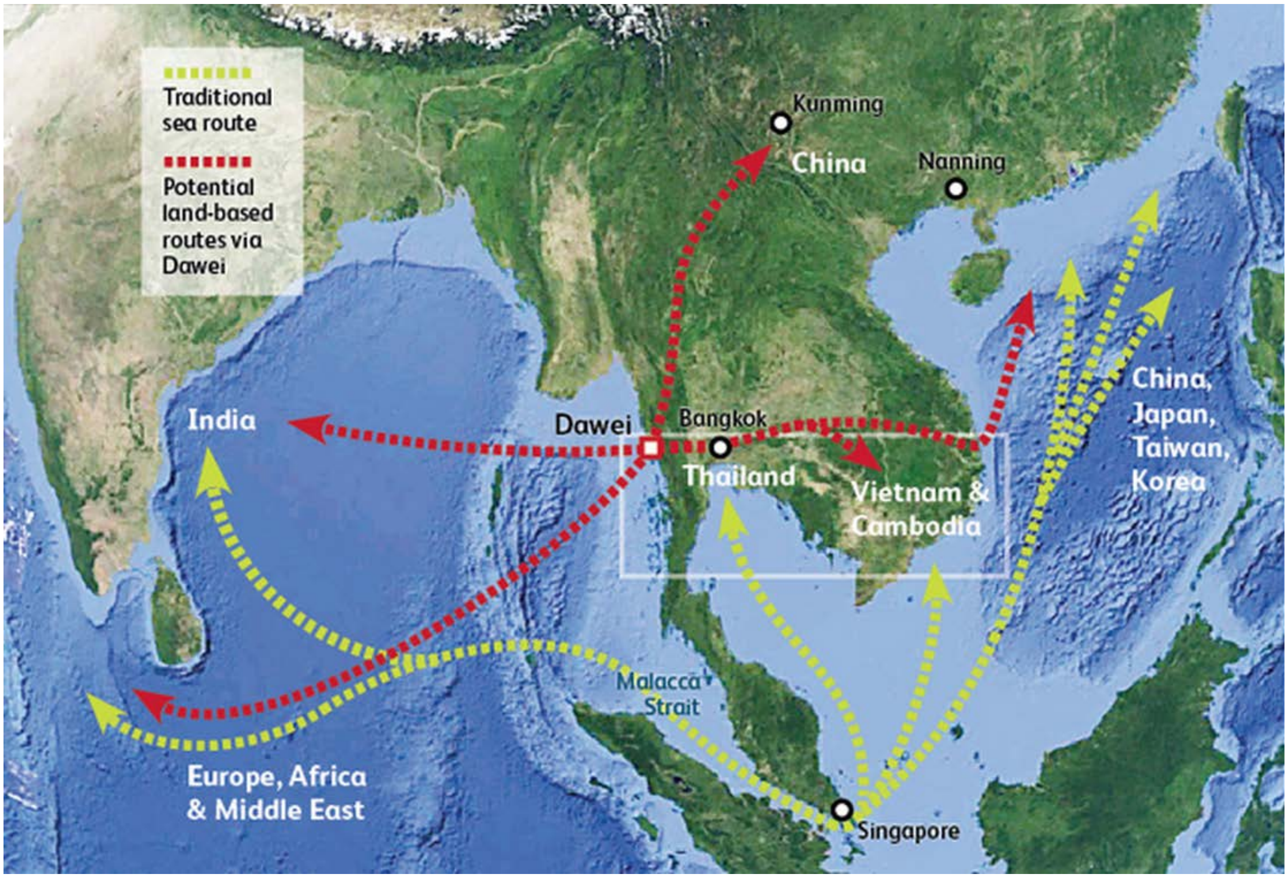


Figure 3. Dawei will be linked to the Greater Mekong Subregion Southern Corridor.[33]

---

[32] Chachavalpongpun, 2011.
[33] ITD, 2013a.

The project occupies a vast area of land, covering 250 square kilometers or about 97 square miles in total.[34] In February, 2012, ITD revised the plan and reduced the size of the project to 204.5 square kilometers[35].

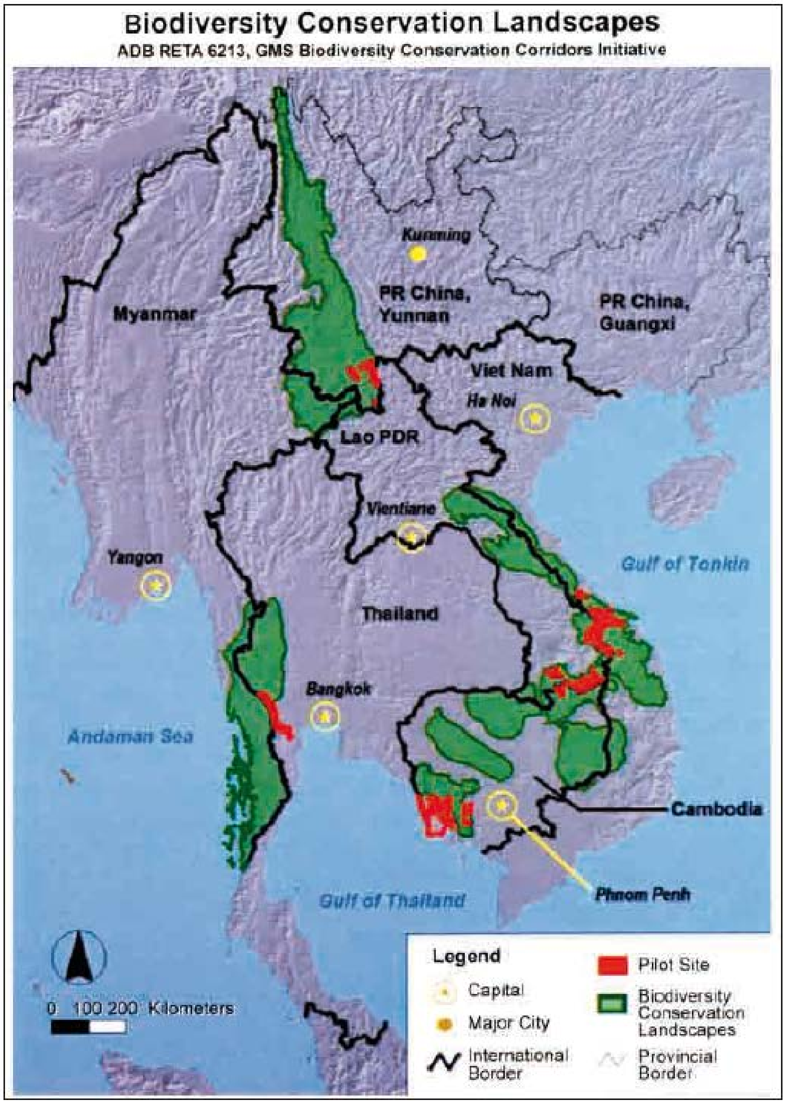
Social Context. The total population of Dawei city and surrounding region is estimated to be around 500,000.[36] The region is home to the Tavoyan, Mon, and Karen populations with their long standing cultures, customs, languages, and social structures. The majority of the Tavoyan and Mon populations live by the coast while the Karen mostly live in mountainous areas. The Tavoyan and Mon depend on agriculture and fishing for food and income. The Karen depend on agriculture, including the practice of slash and burn in mountainous areas. The populations in Dawei have a self-sufficient, subsistence-based lifestyle. Families get vegetables from their gardens, fish from the rivers, and meat from their livestock. They also get income from agricultural products including betel, areca nut, rubber, palm oil, cashew, tropical fruits, and orchids.[37] An estimated 85 percent of the local populations rely on plantation agriculture for their livelihoods.[38]

The Dawei region is also of historical importance. Buddhist relics and ancient artifacts have been dated back to the 6th century, suggesting that Dawei was home to an ancient civilization that flourished from regional trade. The area is home to some of the oldest Buddhist temples. Although there is no clear historical record, it is widely believed that Buddha visited the area over 2550 years ago and left a footprint as well as a buffalo footprint (the symbol of Buddha's previous life) in Nabule, which lies directly within the Dawei Special Economic Zone area. This is the only left-foot footprint of Buddha in Burma, making Dawei an important religious site for the local population and Buddhists from other parts of the country.[39]

Environmental Context. The region is ecologically diverse, with "forested mountains, rushing waterfalls, rivers which flow with rich aqualife, and pristine Andaman beach surrounded by nearby island(s)".[40] It is located within the Tenasserim Biodiversity Conservation Landscape (Figure 4)[41], which is classified as tiger conservation landscape Class I (supporting more than 100 tigers and having evidence of breeding) and is a global priority for tiger conservation. The area is also home to many globally threatened bird species. The Wildlife Conservation Society of Thailand is currently conducting an initiative called "Tenasserim Biodiversity Conservation Corridor" to connect important core protected areas of the Western Forest Complex and Kaeng Krachan Forest Complex (both located within Thailand). The Corridor is within Thailand's territory but lies along Burma-Thailand border. A study in 2006 reveals that the Corridor supports 20 species of large- and medium-sized mammals and 4 hornbill (bird) species, 16 of which are on the IUCN Red List of Threatened Species, a list that identifies particular species that are at risk of extinction. The Corridor is essential for maintaining habitat connectivity and enabling species' adaptation to climate change. However, the Dawei project's road and rail links between Dawei and Bangkok will cut through this important Corridor, with potential negative impacts on biodiversity (Figure 5).

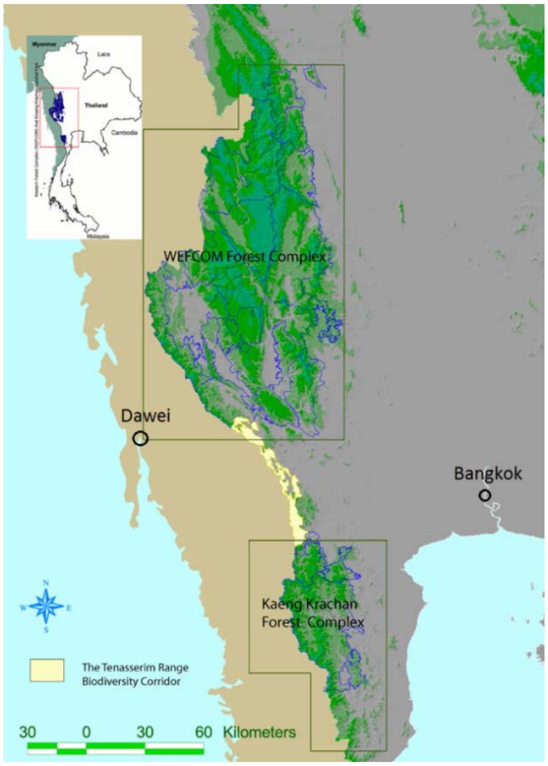
[34] The New York Times, 2010.
[35] Thabchumpon et al., 2012.
[36] Paung Ku and Transnational Institute, 2012.
[37] Dawei Project Watch, 2012.; EARTH et al., 2012.
[38] Paung Ku and Transnational Institute, 2012.
[39] Paung Ku and Transnational Institute, 2012.
[40] Paung Ku and Transnational Institute, 2012
[41] Wildlife Conservation Society of Thailand, 2010.

Figure 4. Tenasserim Biodiversity Conservation Landscape, ADB's Greater Mekong Subregion Biodiversity Conservation Corridors Initiative[42]



[42] Wildlife Conservation Society of Thailand, 2010.

Figure 5. Tenasserim Biodiversity Conservation Corridor[43]



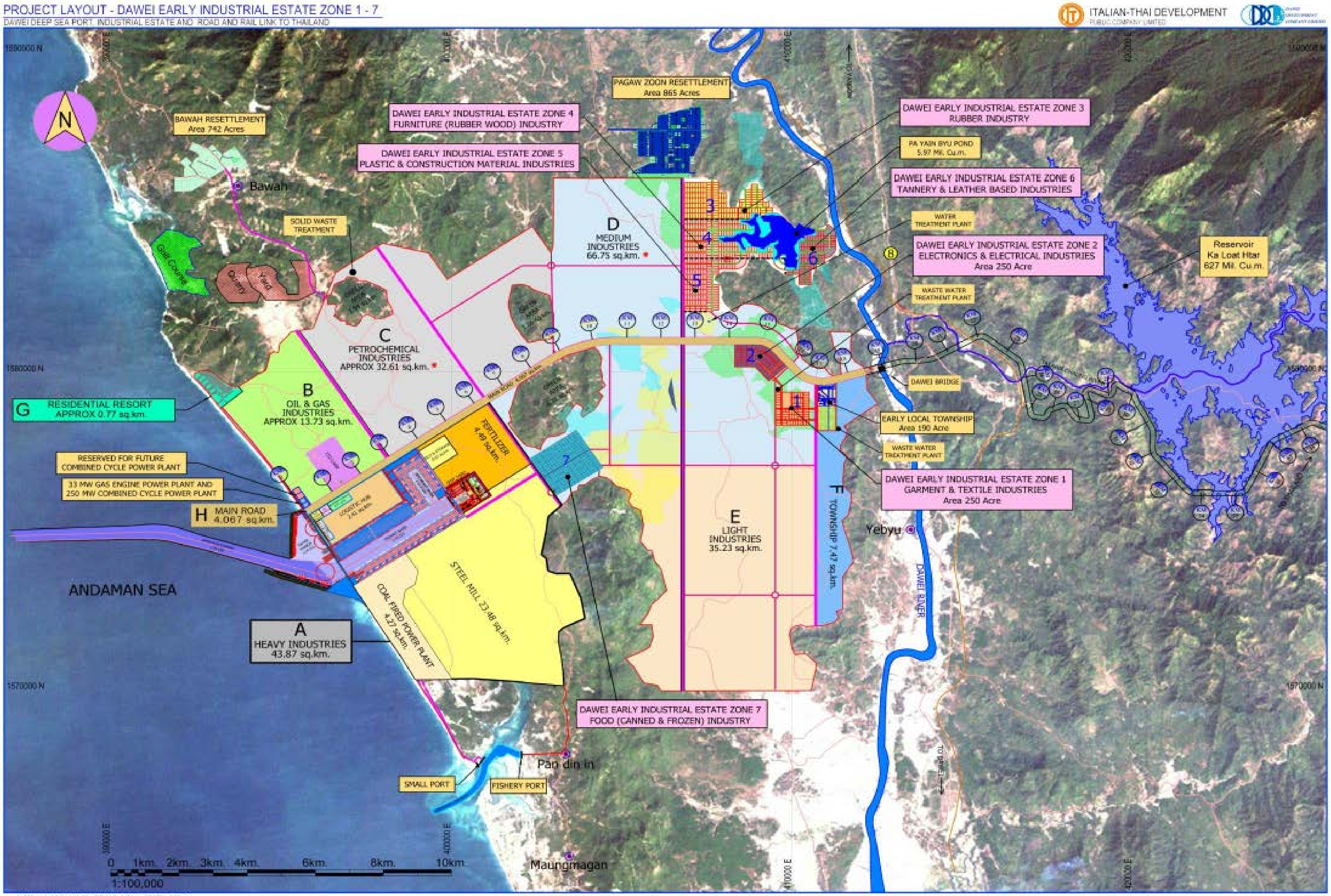
PROJECT ASSETS AND OPERATIONS

The Dawei project led by Dawei Development Company Limited, a subsidiary of ITD, has the potential to become the largest Special Economic Zone in Southeast Asia. It seeks investment and participation from potential strategic partners in 18 sectors, including port, power plant, toll road, water infrastructure, railway, telecommunication infrastructure, medium and light industrial estate, shipyards, commercial and residential township, fertilizer plants, refinery and gas complex, petrochemical complex, chemical complex, logistics, integrated steel mills, utility services, pulp and paper, and a world class holiday resort (Figure 6). The planned project layout is presented in Figure 7.

Figure 6. Dawei Project Investment Structure[44]

[43] Wildlife Conservation Society of Thailand, 2013.
[44] ITD, 2013a.

Figure 7: Dawei Planned Project Layout[45]



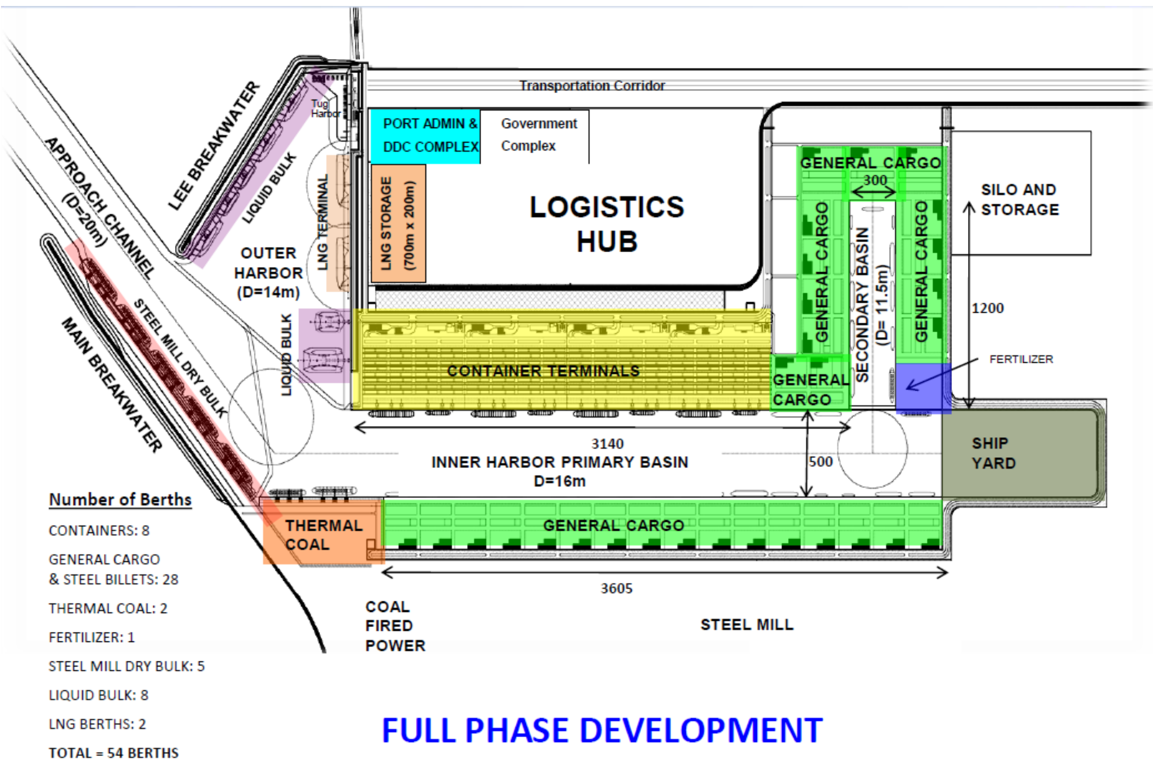
---

45 ITD, 2013a.

Specifically, the main components of the project as proposed by ITD include:

- **Deep seaport** with a total of 54 berths, able to accommodate up to 300,000 deadweight ton vessel and capable of handling 250 million metric tons of goods per year (see Figure 8) for the planned layout of the port). The port will have an integrated logistics hub with intermodal freight transport capabilities. It will service liquid cargo, agricultural products, general cargo, containers, as well as bulk cargo.[46] As of May 2013, ITD stated that it has completed compensation payments to villagers in the area of the deep seaport.[47]
- **Small port** with a 100-meter long jetty berth, capable of handling 250-400 twenty-foot equivalent unit container ships (see Figure 9 for location of the small port). The small port is being built and will be completed in 2013 (see Figure 10) for the status of the small port as of June 2013).

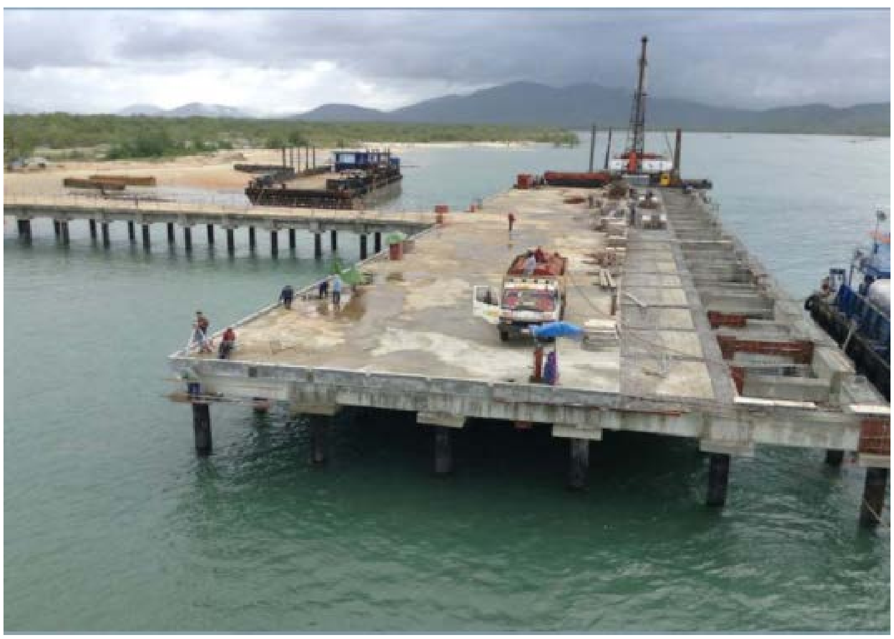
Figure 8. Full phase development layout of the Dawei deep seaport project.[48]



[46] ITD, 2013a; ITD, 2013f.
[47] ITD, 2012.
[48] ITD, 2013a.

Figure 9. Location of the small port.[49]

Figure 10. Small port as of June 15, 2013.[50]

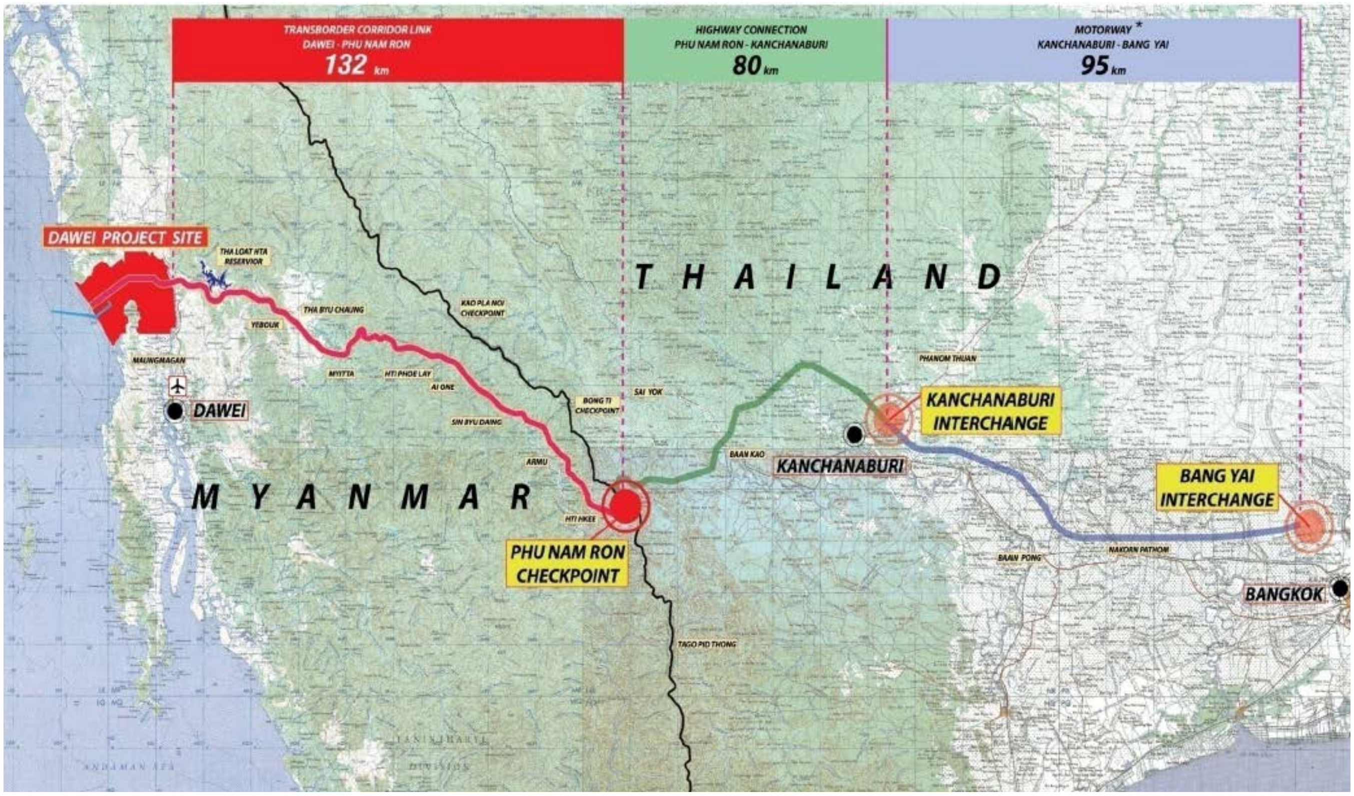


- **132 km highway** connecting Dawei to the border of Burma and Thailand at Phu Nam Ron. The highway will initially consist of 4 lanes and will be expanded to 8 lanes in the future. As of July 2013, ITD has completed the access road between Dawei and Phu Nam Ron and is beginning the construction of the highway. In addition, the Thai Department of Highways in the Ministry of Transport will construct an 80 km highway connecting Phu Nam Ron and Kanchanaburi, and a 95 km motorway connecting Kanchanaburi to Bang Yai next to Bangkok (see Figure 11 for the layout of the transborder road link). The road link will enable travel from Dawei to Bangkok within about five hours. It will eventually be connected to the Greater Mekong Subregion Southern Corridor to reach seaports in Vietnam.

[49] ITD, 2013a.
[50] ITD, 2013e.

- **Rail link** connecting Dawei-Yangon (Rangoon)-Mandalay-Muse, which will be further linked by the Chinese railway system to the city of Kunming, China.

Figure 11. Road Link, detailed designed of the "Kanchanaburi – Bangyai" Motorway completed by the Thai Department of highways, Ministry of Transport.[51]



- **Industrial estate** consisting of five zones: (1) oil and gas industries, including oil refinery, tank farm, gas separation plant, and combined cycle power plant; (2) petrochemical industries; (3) heavy industries, including steel mill, fertilizer plant, coal fired power plant; (4) medium industries, including manufacturing of auto tire, paper, gypsum, rubber, automotive assembling plant, and steel fabrication yard; and (5) light industries, including garment factory, cosmetics, computer parts, and food processing plant (see Figure 7 for the layout of the industrial zones).
- **Coal-fired power plant**. ITD originally proposed a plant with a capacity of 4,000 MW, from which 3,600 MW would be exported to Thailand. However, the plan was rejected by the government of Burma in January 2012.[52] ITD then redesigned the project to build a 600 MW plant only to supply the domestic demand of the project. The company indicated that the 600 MW plant will be built with clean coal technologies and completed by 2017.[53] As of May 2013, ITD reported (without independent verification) that it has completed compensation payments to villagers in the area of the coal-fired power plant.[54]
- **Dam and reservoir** with a capacity of 500 million cubic meters, as well as a water purifying plant that can provide 975,000 cubic meters of water a day.[55] As of July 2013, ITD has relocated residents from the

[51] ITD, 2013a.
[52] Thabchumpon et al., 2012.
[53] ITD, 2013d.
[54] ITD, 2012.
[55] Thakhin, 2011.

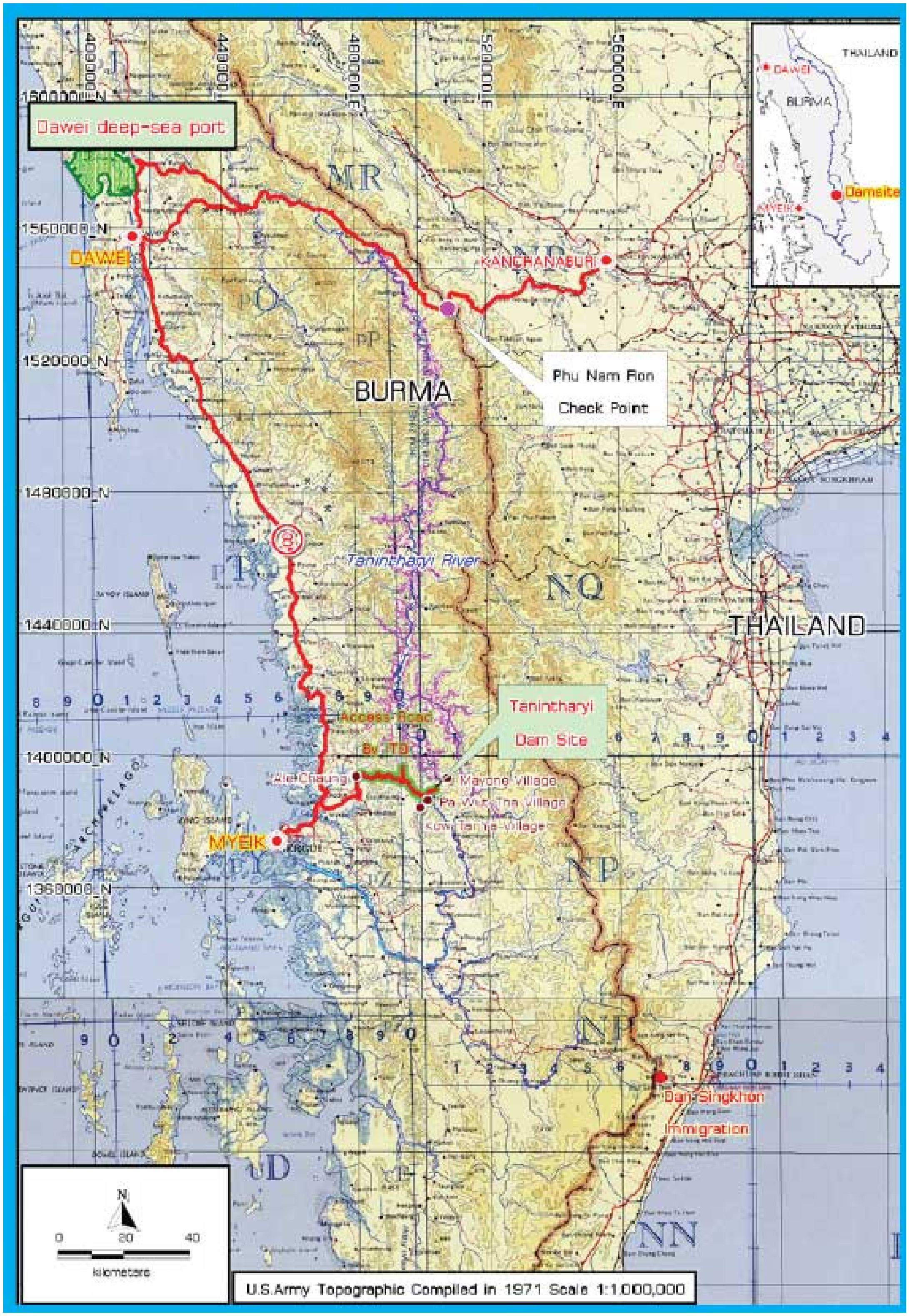
reservoir site and reports that it completed compensation payments for some. Construction of the dam and reservoir is well underway (Figure 12).[56]

- **1040 MW hydropower project** at Tanintharyi. The hydropower project is situated outside of the Dawei project site (Figure 13) but all energy will serve the Dawei industrial estate.[57]
- **Residential and commercial housing** for local residents and expatriates, two golf courses, a tourist resort, and a recreation complex aimed to boost tourism industry in the region.[58]

Figure 12: Dam Construction: Transition Wall and Slap Casted Progress (July, 2013)[59]

[56] ITD, 2013e.
[57] ITD, 2013g.
[58] ITD, 2013a.
[59] ITD, 2013e.

Figure 13: Location of the Tanincharyi Hydropower Project (red lines are roads)[60]



---
[60] TEAM Consulting Engineering and Management Co., Ltd., 2013.

Environmental and Social Impacts

Economic Benefits

The project can provide economic benefits to the Dawei area and Burma, including local employment, increased Foreign Direct Investment, and tax benefits to the Burmese government.[61] The President of ITD stated that the Dawei Special Economic Zone would generate a large number of jobs and will "mobilize millions of Burmese" over the long term. Over the first five years of construction, the company expects to hire tens of thousands of employees.[62] The project will bring much-needed infrastructure to Burma after decades of economic isolation and stagnation. It will also enable knowledge and technology transfer and boost the growth of local business and industries.[63] As the United States and European Union lift sanctions on Burma in response to the country's democratic reform, Dawei presents an opportunity for Burma to integrate into the global economy. It is hoped to change Burma in the same way that Shenzhen Special Economic Zone marked China's industrial transformation three decades ago.[64] Furthermore, the Dawei project will strengthen regional trade through establishment of economic corridors between Burma, Thailand, Laos, Cambodia, and Vietnam.[65] Regional and national economic growth is expected to translate into higher standards of living for Burmese citizens.

Environmental and Social Concerns

A mega-development project like Dawei can have significant adverse impacts on the local environment and community. ITD indicates that an Environmental Impact Assessment and Social Impact Assessment have been completed as required by Burma's new environmental law. However, as of August 2013, the Assessments have not been made available to the public. As a result, most of the environmental and social concerns presented here are from civil society reports and newspaper articles.

Environmental Concerns. While no official study is available, the environmental impacts of the Dawei project are likely to be substantial given the size of the investments in a largely undeveloped region. Massive infrastructure development and increase in economic activity in the Dawei project will damage the region's pristine coastline and its relatively untouched wilderness area. The deep seaport alone is expected to clear 35 square kilometers of mangrove forests, which can reduce protection from wind and wave action and increase coastal erosion.[66]

The corridor from Dawei to the border town of Thailand will consist of roads, railways, transmission lines, and oil and gas pipelines, cutting through forest areas including the Tenasserim Biodiversity Conservation Corridor. The road and rail link will contribute to habitat fragmentation and forest degradation, with negative consequences on wildlife and biodiversity in the Thai-Burma Tenasserim mountain range region, which will likely impact the critical tiger population there.[67]

It is also estimated that the project will need about 2,150 million cubic meters of water per year, which will put a strain on water resources in the region, especially the Dawei River in the dry season.[68] The dam and reservoir will help ease water supply stress but may alter the river ecosystem and affect local fisheries. In addition, waste from coal, petro-chemical, fertilizer, steel, and other industries can cause air and water pollution that will affect fishing and farming activities and result in major health impacts. Fuel waste from ships and petrochemical waste

[61] ITD, 2013a.
[62] The New York Times, 2010.
[63] ITD, 2013a.
[64] The New York Times, 2010.
[65] ITD, 2013b.
[66] Thabchumpon et al., 2012.
[67] U Tin Than, 2012.
[68] EARTH et al., 2012.

from factories can damage coastal ecosystems, including the ecologically sensitive Mergui archipelago that comprises over 800 islands and 600 species of coral reefs.[69]

Social and Cultural Concerns. In addition to the environmental impacts, the project will have several socio-cultural impacts that affect the people who currently live in the region. It will cause massive resettlement of the local residents, which has already started. There is not yet any official estimate of the total population that require resettlement, but various civil society groups report that over 30,000 people from about 20 villages will have to move to make way for the Special Economic Zone of 204.5 square kilometers (or 50,533 acres).[70] In addition, about 182 households in the dam and reservoir area of 7 square kilometers (or 1730 acres) were expected to be relocated, which appears to have occurred as the dam and reservoir construction is well underway as of May 2013.[71] The road link between the port and Thai-Burma border will displace an additional 1,500 people.[72] Most of the affected populations in the coastal area belong to the Tavoyan ethnicity, while those impacted by the dam and road construction are mostly from the Karen ethnicity.

The project will transform the Dawei area from a subsistence-based, self-sufficient agricultural economy to an industrialized, export-oriented special economic zone, thus fundamentally changing the social and economic fabric of the region.[73] ITD plans to construct four Special Economic Zone relocation sites, including Bawar (800 acres), Htwet Wa (300 acres), Wazwam Taw (1,500 acres), and another site 3 km (2 miles) south of Kalone Htar (300 acres). A simple calculation shows that the sum of the relocation site areas (2,900 acres) is significantly lower than the amount of land (50,533 acres) that ITD acquired for the Special Economic Zone.[74] Each household will therefore receive a fraction of the amount of land that they previously occupied and used for agriculture, fishing and other livelihood activities. As seen in Figure 14 and Figure 15 below, the company allocates a new house to each household, with no obvious arable land around it for residents to continue their agricultural activities. Overall, the industrial estate and road and rail links will destroy thousands of acres of paddy cultivated lands, rubber plantations, cashew nut plantations, betel plantations, and orchid plantations.[75] Another 3,233 acres of farmland will be acquired to develop the relocation sites, depriving more farmers of their livelihoods.[76] The permanent loss of agricultural land will cause loss of local livelihoods and create economic insecurity.[77]

The project is expected to generate a large number of jobs, but most local residents fear that they are not qualified to work in the Special Economic Zone since they have fished and farmed their entire lives and lack other skills. Many, if not most, jobs could go to skilled workers who are expected to migrate into the area, while the local residents may be hired for low-skilled, hard-labor jobs with comparable pay to what they currently earn.[78]

While Burma is making democratic reforms, the country is still in a transitional period. Burma's rules and regulations regarding land ownership and environmental, social, and health impacts are reportedly weak and provide little protection to the local residents at Dawei.[79] Furthermore, the public has been largely excluded from the Dawei development process. Interviews with local residents in late 2011, early 2012 revealed that they were not properly informed by the local government and ITD about the scope of the project. The residents were simply told that they would have to move, but did not know where they would relocate to, when they would

[69] Yeni, 2011.
[70] Thabchumpon et al., 2012; Dawei Project Watch, 2012; Aung, 2012; Paung Ku and Transnational Institute, 2012.
[71] Paung Ku and Transnational Institute, 2012.
[72] EARTH et al., 2012.
[73] Thabchumpon et al., 2012.
[74] Paung Ku and Transnational Institute, 2012.
[75] Dawei Project Watch, 2012.
[76] Paung Ku and Transnational Institute, 2012.
[77] Thabchumpon et al., 2012.
[78] Dawei Project Watch, 2012.
[79] Thabchumpon et al., 2012.

have to relocate, how much compensation they would receive and when, and what they would do for a living after relocation.[80] They are concerned that they would not be adequately compensated for their losses of land. And, even if ITD paid full compensation, residents feared that the government might appropriate most of the money as in the case of a French gas pipeline 15 years ago in Kanbauk not far from Dawei. The lack of information and past experience has created fear among the residents – some have reportedly stopped working on their plantations, feeling that it is meaningless to continue growing crops on land that would eventually be confiscated. The interviews also suggested that residents were also not aware of the potential impacts the industrial complex can have on their health.[81]

In fact, several cases of forced and unfair land compensation have been reported. According to a report by Earth Rights International, the plantation owners in Mindat village of Yebyu Township were forced to sign agreements to sell 123 acres of land to the Dawei deep seaport project in September, 2011. The owners did not want to sell, but were told that their land would be confiscated whether they signed the agreements or not, leading to fears of losing their land without compensation. The amount of compensation was reported to be well below the market price of land.[82]

In addition to land acquired by ITD to develop the Dawei project, local residents reported that they have been forced into selling properties below market values due to speculation of economic growth in the region. The area is reported to have experienced an influx of investors and businessmen from Thailand and other parts of Burma. They are not directly associated with ITD but came to buy properties not located in the project area, hoping to later sell the land at a much higher price or opening businesses near the Special Economic Zone. An interview with one Dawei land broker revealed that in some cases, local prices of farmland have increased by 15 times compared to before the Special Economic Zone plan. The local residents are usually not aware of the price tag and fear consequences if they resist the offer from foreign and Burmese elites. The number of local residents who will be displaced could therefore be much higher than originally estimated.[83]

The project will affect 23 cultural and religious buildings, including a national revered pagoda with Buddha's footprint in the village of Nabule. ITD stated that they would not relocate these important heritages (monasteries, temples, and pagodas) but the villagers would have to move. Without anyone to worship and maintain them, the heritages may deteriorate and lose its cultural history. As residents are uprooted from their land, their traditional community structure will be affected. Residents are also concerned that an influx of migrants into the Dawei Special Economic Zone can change the cultural fabric of their hometowns.[84]

[80] Dawei Project Watch. 2012.
[81] Dawei Project Watch, 2012.
[82] Thakhin, 2011.
[83] Paung Ku and Transnational Institute, 2012
[84] Dawei Project Watch, 2012.

Figure 14. A Relocation Area of the Dawei Project.[85]

Figure 15. A Finished House in a Relocation Area of the Dawei Project.[86]

ENVIRONMENTAL AND SOCIAL COMMITMENTS

Since the Environmental Impact Assessment and Social Impact Assessment have not been made publicly available, there is currently little information on the environmental and social commitments of the project. ITD states on the project website that it “strongly realizes the impact on environment, social acceptance, and health which may occur as a result of [our] industrial development”. It indicates that the Environmental Impact Assessment and Social Impact Assessment will include mitigation measures and monitoring plans. In addition, ITD will prepare a Resettlement Action Plan to provide the framework for compensation, relocation, and livelihood restoration programs for the local communities. Due to the absence of requirements from Burma’s former military government, ITD has started construction before the Environmental Impact Assessment, Social Impact Assessment, and Resettlement Action Plan were completed.

[85] ITD, 2013a.
[86] ITD, 2013a.

Although independent verification is not possible at this time, ITD states that the company is committed to using the best technical practices to save energy and reduce waste and pollution. It established an in-house division on environmental issues to monitor the environmental impact of the project construction and operations. The company is also carrying out several social and environmental projects, including:

- **Corporate Social Responsibility Projects**, such as community development, education, basic medical service, and local tradition and cultural activities;
- **Training and Career Development Projects**, such as training programs and guidelines for traditional agricultural and fishery productions;
- **Environmental Restoration Projects**, such as environmental and natural resources management, re-landscaping, seedling center, plant nursery, and taking actions to prevent erosion for both soil and coastal line, and developing a green industrial zone (using new technologies to save energy and reduce waste); and
- **Public Participation Projects**, including increasing participation of all government sectors and the public into the project.[87]

ADHERENCE TO ENVIRONMENTAL AND SOCIAL COMMITMENTS

Since ITD's environmental and social commitments regarding compensation and restoration of livelihoods for local residents remain unclear, it is not possible to fully assess ITD's adherence to its commitments. In its 2012 Annual Report, ITD stated that it completed payments to villagers in the area of the deep-seaport, the main road in the Special Economic Zone, and the coal-fired power plant. Local contractors have partially completed the first phase construction of relocating housing.[88] Additionally, ITD indicates on its website that it is implementing several social and environmental projects as part of its corporate social responsibility commitments at Dawei.

The projects include construction of a Buddhist pagoda to promote mutual understanding and cultural exchange between Thailand and Burma, setting up a regular health check-up program, distributing mosquito nets and insect repellent that can be applied to skin or clothing to reduce malaria, constructing a hospital within the Dawei complex, providing basic computer training to local residents, and organizing a market for local residents to sell their agricultural products without rental fee. It also promises to conduct a Public Consultation for the Environmental Impact Assessment of the highway between Dawei and Thai-Burma border.[89]

However, interviews with local residents suggest that many concerns remain regarding the issues of compensation, loss of livelihoods, and change of cultural and social fabric (see the Environmental and Social Impacts section for more detail). Furthermore, villagers reported that they were not properly informed prior to and during the Public Consultation for the highway's Environmental Impact Assessment. The Thai surveyors did not inform villagers of the purpose of the meeting nor share the findings of the Environmental Impact Assessment. They distributed forms and asked the villagers to fill them out, which the villagers refused to do.[90] Lack of public participation therefore appears to remain a major issue.

Local Conditions

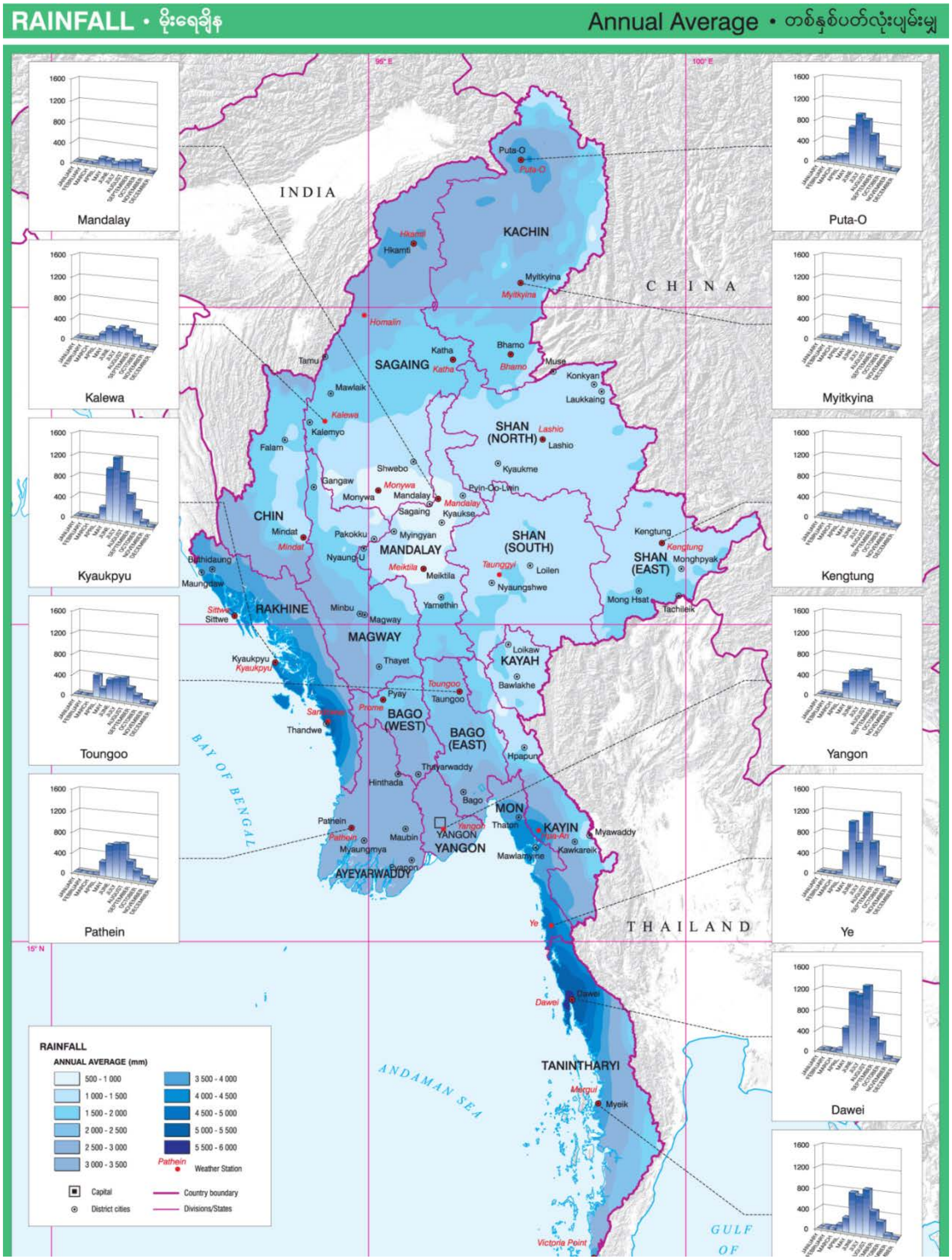
CURRENT LOCAL CLIMATE

Burma has a tropical monsoon climate. The hot rainy season lasts from May to October and is driven by the southwest monsoon. The cool dry season lasts from November to April and is driven by the northeast monsoon. Precipitation varies among regions due to differences in topography, which in turn affects exposure to the southwest monsoon. The coastal areas where Dawei is located receives annual rainfall of as high as 5,000 mm

[87] ITD, 2013h.
[88] ITD, 2012.
[89] ITD, 2013i.
[90] Saw Eh Na, 2013.

(~200 in), while annual rainfall is only 600 mm in the central lowlands (dry zone) (see Figure 16).[91] Average monthly temperatures at Dawei range from 17°C (63°F) to 26°C (79°F).[92]

Figure 16. Annual Average Rainfall in Burma (FAO, 2009).



[91] Baroang, 2013.
[92] World Bank, 2013.

CLIMATE CHANGE PROJECTIONS

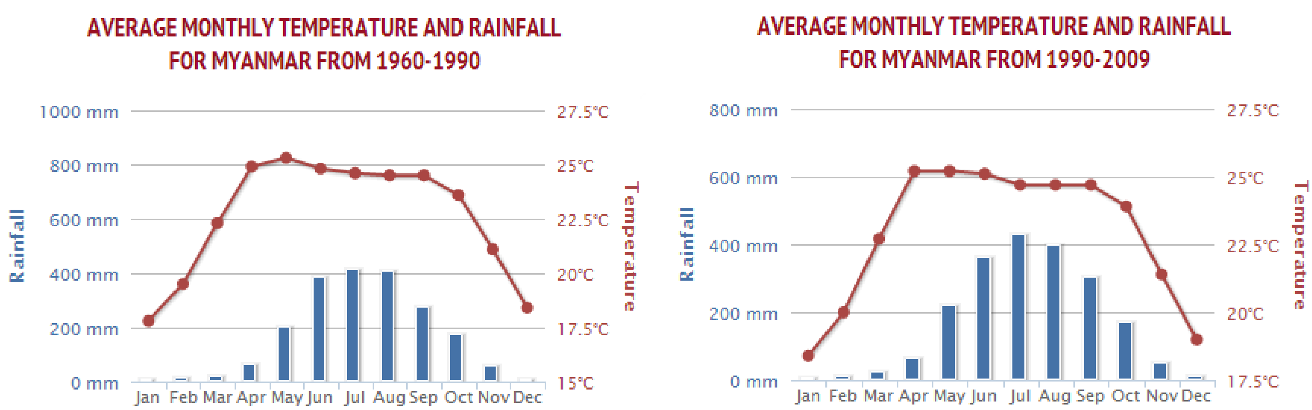
According to the UNFCCC website, Burma submitted its Initial National Communication on Climate Change on December 26, 2012.[93] However, the document is still under review and not yet available to the public. Information on climate trends and projections presented in this document is based on the World Bank's Climate Change Knowledge Portal (CCKP) tool, a background paper for USAID/Burma-funded project "Strategic Agricultural Sector and Food Security Diagnostic for Burma" (Baroang, 2013), and a study by Regional Integrated Multi-Hazard Early Warning Systems (RIMES, 2011).

Overall, Burma is projected to experience an increase in temperature, an increase in total rainfall and heavy precipitation during the wet season, and an increase in sea level rise due to climate change. The increase in heavy precipitation during the rainy season coupled with sea level rise can lead to increased flood risks in coastal areas. However, as there is a lack of high quality historical climate data for Burma, the climate trends and projections presented in this document should be taken with caution.

Temperature and Precipitation

Historical Trends. According to the Burma's Ministry of Agriculture and Irrigation, there has been an upward trend in temperatures and a downward trend in rainfall between 1960 and 2000 for the country. The Ministry's analysis also suggested that the monsoon duration has decreased by around 0.5 days per year on average between 1955 and 2008. While there is agreement on the upward trend in temperatures, other studies suggested that there has been no significant trend over recent decades for rainfall totals or extremes.[94] For example, the World Bank's CCKP shows that there has been a slight increase in average monthly temperatures but no significant trend in average monthly precipitation for Burma between 1960-1990 and 1990-2009 (Figure 17). More research will therefore be needed to understand recent precipitation trends.

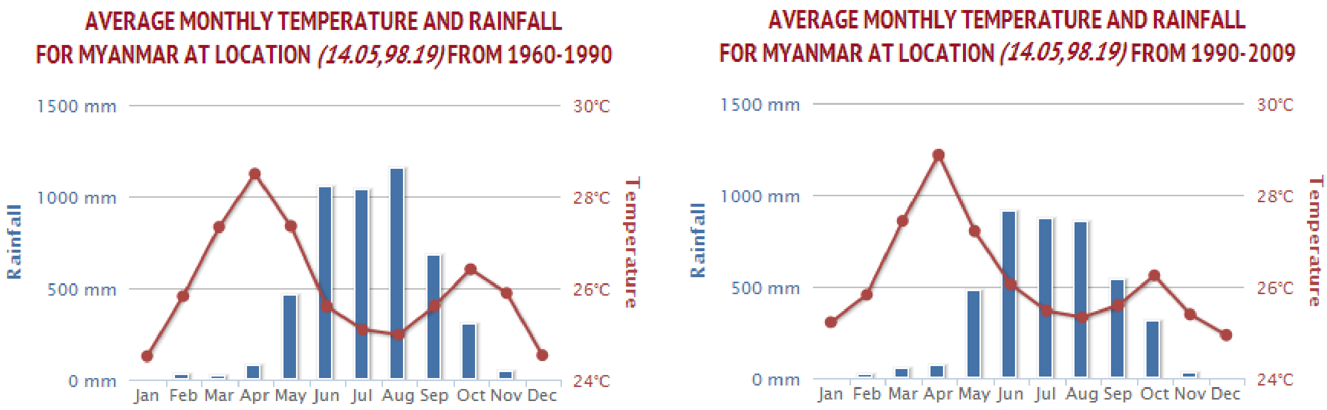
Figure 17. Average Monthly Temperature and Rainfall for Burma from 1960-1990 and 1990-2009[95]



The World Bank's CCKP tool was used to generate site-specific temperature and precipitation trends. At Dawei, average monthly temperatures have slightly increased in recent decades, while average monthly rainfall has decreased for the months of June to September (the rainy season driven by the southwest monsoon) (Figure 18). However, as mentioned above, more research is needed to understand recent precipitation trends.

[93] UNFCCC, 2013.
[94] Baroang, 2013.
[95] World Bank, 2013.

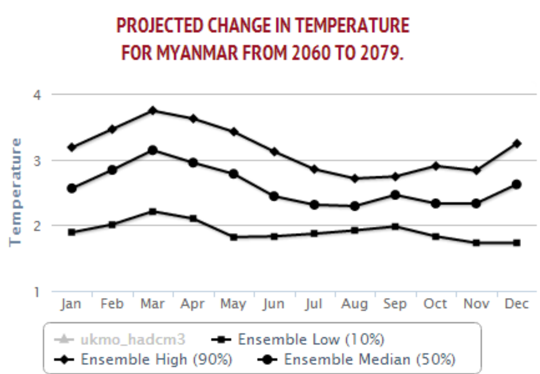
Figure 18. Average Monthly Temperature and Rainfall at Dawei from 1960-1990 (left) and from 1990-2009 (right)[96]



Projections. The World Bank's CCKP tool was used to generate temperature and precipitation projections for the entire country of Burma and for Dawei. The time period 2060-2079 was chosen as it corresponds to the 60-year concession that ITD received for the Dawei project (2010-2070) and because major port facilities generally have economic design lives on the order of 50-80 years.[97] For variables whose projections for the 2060-2079 period are unavailable (e.g., number of hot days, number of days with extreme rain), the 2081-2100 period was used because the data were provided. An ensemble of nine Global Circulation Models (GCMs) was used to capture the range of possible temperature and precipitation changes relative to the 1980-1999 baseline. The models were run using the moderately-high A2 emissions scenario.

Climate models suggest an increase in average monthly temperature of 1.7 to 3.7°C by 2080 relative to the 1980-1999 baseline (Figure 19). This is consistent with projections of a 1 to 4°C increase in average annual temperature by 2100 relative to the 1961-1990 baseline from RIMES (2011). Average daily maximum temperature is projected to increase and can reach nearly 40°C in April by end of century (Figure 20). The number of hot days[98] is also expected to increase by 2100, particularly between March and June (Figure 21).

Figure 19. Projected Change in Average Monthly Temperature for Burma from 2060 to 2079 (°C).[99]



[96] World Bank, 2013.
[97] FHWA, 2012.
[98] Number of days with maximum temperature above the control period's 90th percentile
[99] World Bank, 2013

Figure 20. Historical and Projected Average Daily Maximum Temperature for Burma (°C).[100]

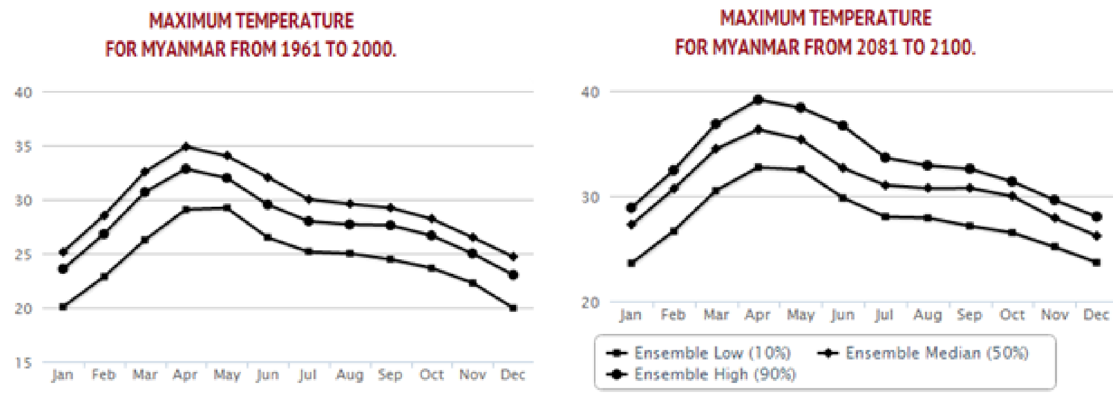
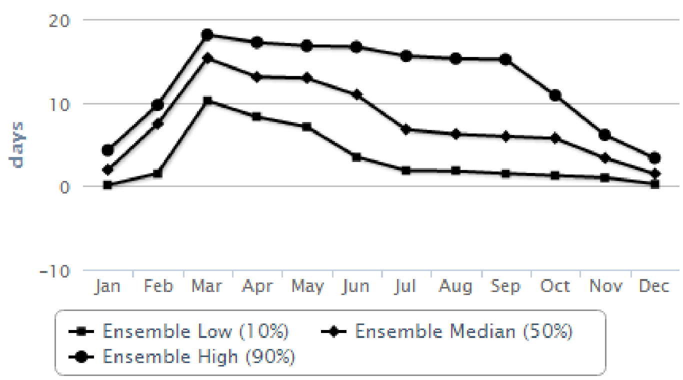


Figure 21. Projected Change in the number of Hot Days for Burma by 2100.[101]



The projections for precipitation are uncertain, with some models suggesting a decrease in rainfall while others indicating an increase. However, the ensemble median suggests that there will be an increase in total rainfall during the rainy season (May to October) by 2080 relative to the 1980-1999 baseline (Figure 22). The projections are consistent with those from RIMES (2011), which suggest a 10% increase in total rainfall for Burma by 2100 relative to the 1961-1990 baseline. In addition, the number of days with extreme rain[102] is projected to increase by 2100, especially during the rainy season (Figure 23).

[100] World Bank, 2013

[101] World Bank, 2013

[102] Number of days with precipitation greater than the control period's 90th percentile

Figure 22. Projected Change in Monthly Total Precipitation for Burma from 2060 to 2079 (mm).[103]

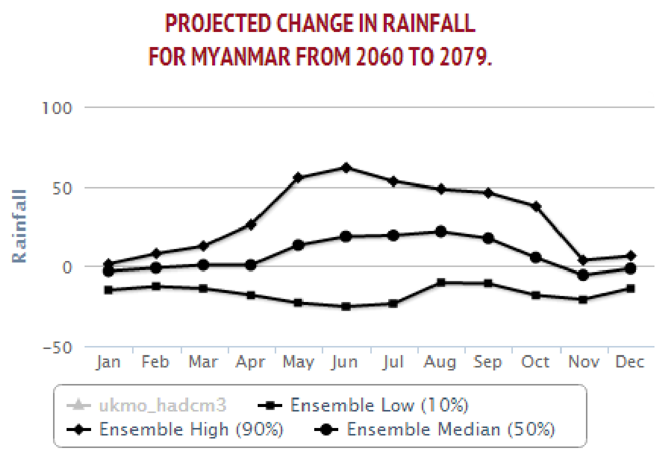
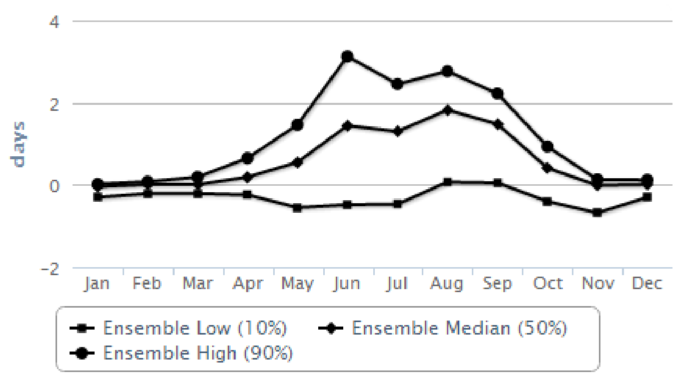


Figure 23. Projected Change in the Number of Days with Extreme Rain for Burma by 2100.[104]

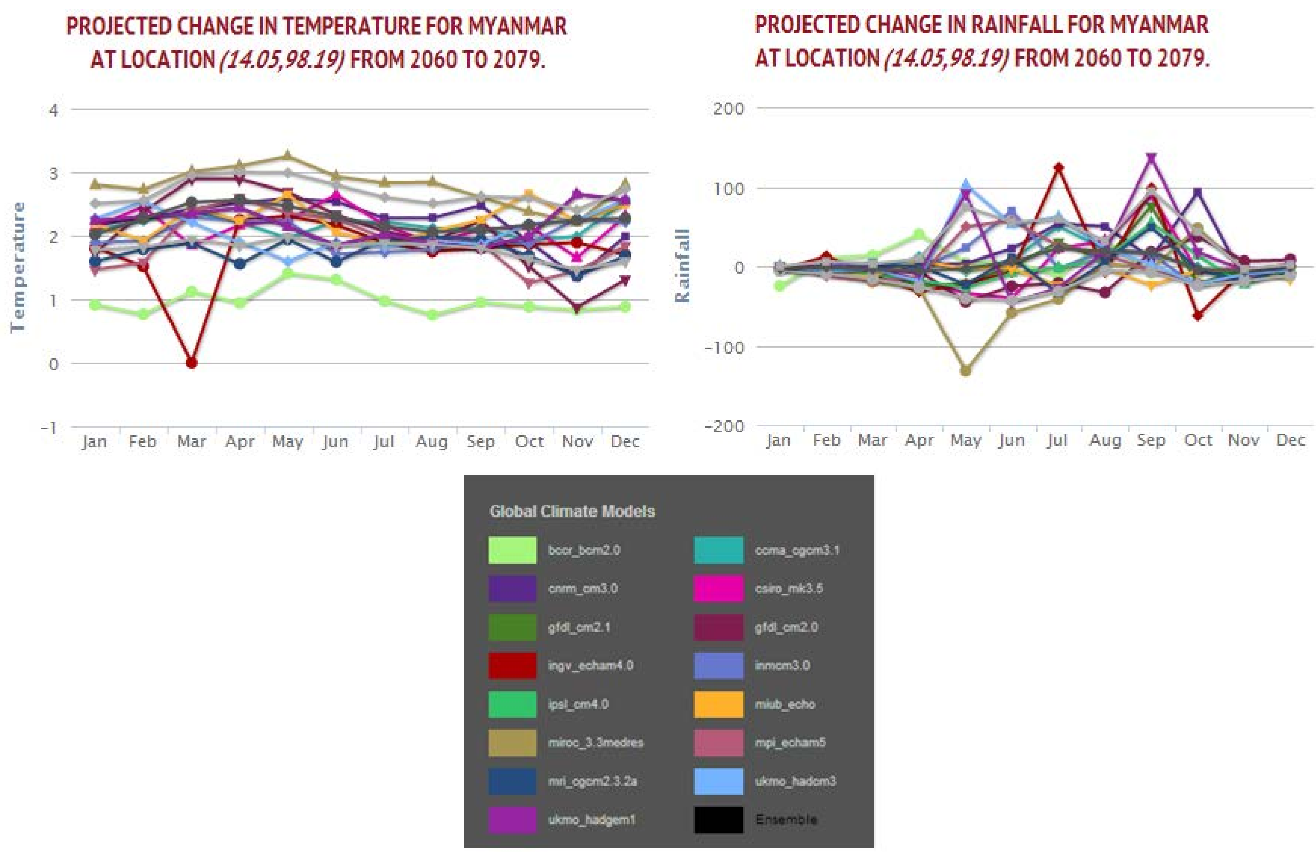


At Dawei, average monthly temperatures are projected to increase by approximately 1 to 3°C by 2080. Future rainfall trends are unclear, with some models indicating a decrease in rainfall while others indicating an increase. However, the ensemble median suggests an increase in rainfall between June and September (Figure 24). The projected changes in the number of hot days and days with extreme rain are unavailable for site-specific areas.

[103] World Bank, 2013

[104] World Bank, 2013.

Figure 24. Projected Change in Temperature and Precipitation for Dawei from 2060 to 2079.[105]



Extreme events and Sea level rise

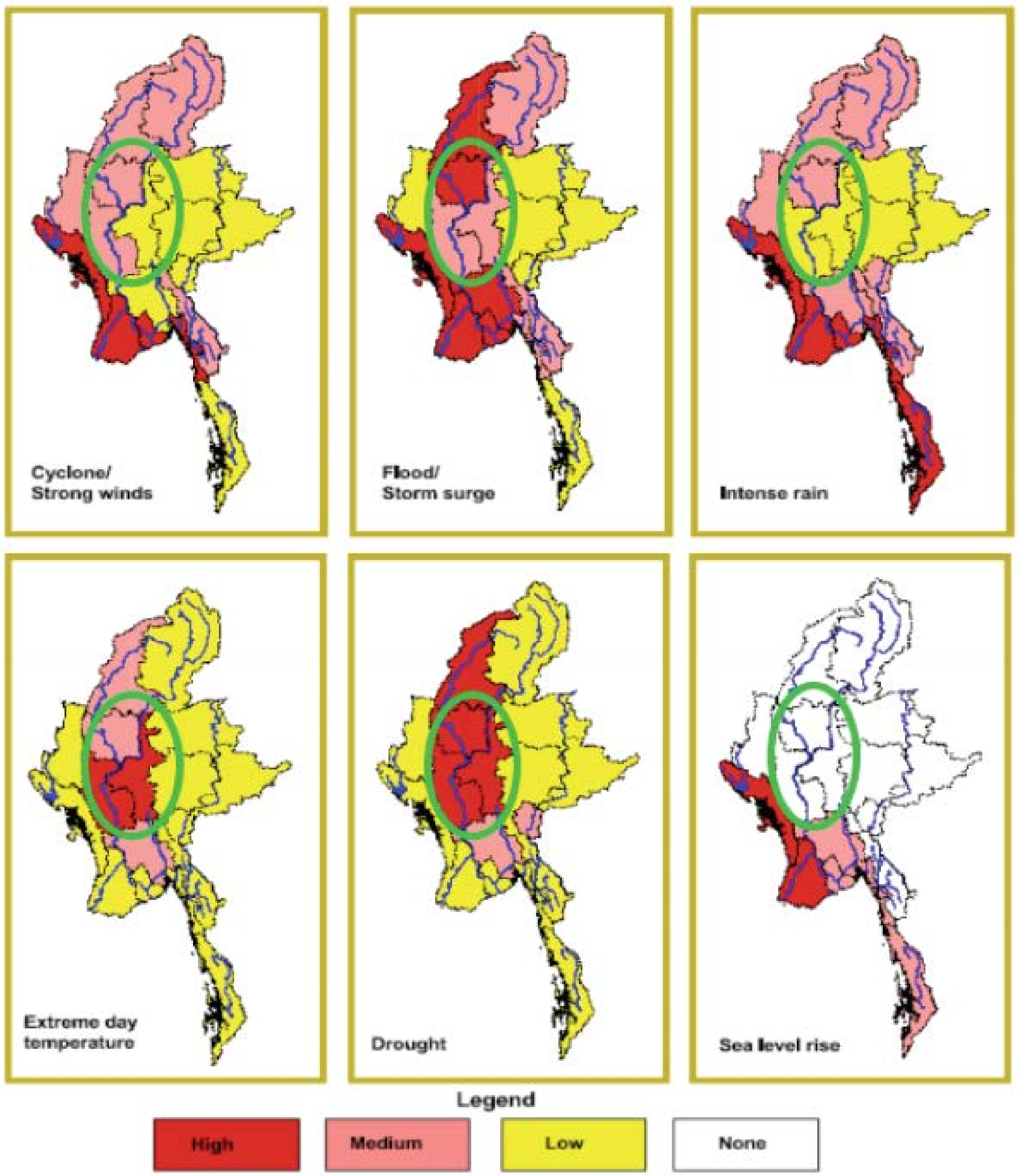
Burma is vulnerable to hydroclimatic extremes and sea level rise. It is highly exposed to cyclones, with a quarter of the country facing flood risk that threatens 36% of the coastal population.[106] The impact of cyclone Nargis in 2008 showed the vulnerability of Burma – the event caused over 140,000 deaths and widespread destruction to the Irrawaddy Delta region.[107]There is uncertainty regarding the projected changes in the intensity and frequency of cyclones. However, on a global level there is consensus that there will likely be a decrease in the global frequency of tropical storms but an increase in their intensity.[108] Sea levels along the coasts of Burma are projected to rise by about 15 cm by 2030 and up to 45 cm by 2070.[109] About 4.6 million people will be vulnerable to sea level rise and storm surges in Burma by 2050, making it one of the most vulnerable countries globally in terms of total populations at risk from sea level rise.[110]

According to a distribution map of disaster risks for Burma (Figure 25), the Thanintharyi Division where Dawei is located is at low risk to tropical cyclone and flooding/storm surge (potentially due to its geographical location and natural shelter[111] – see Figure 26), but is high risk to intense rain and medium risk to sea level rise.[112] A

[105] World Bank, 2013.
[106] Baroang, 2013.
[107] The cyclone did not directly affect Dawei.
[108] IPCC, 2012.
[109] RIMES, 2011.
[110] Wheeler, 2011; ADB, 2012.
[111] One of the reasons ITD selected Dawei for port development is because of its "natural shelter good for anchorage" (ITD, 2013a).

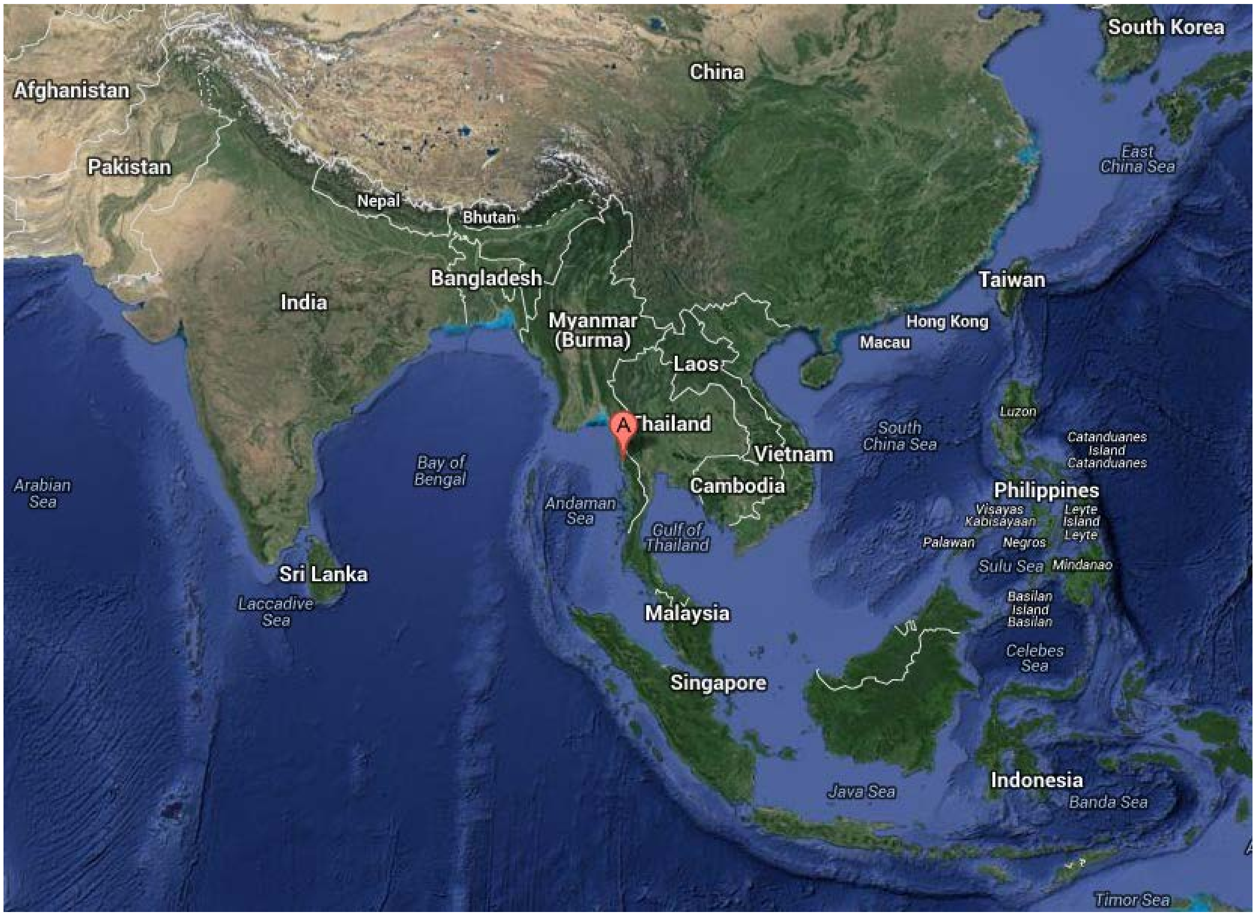
combination of increase in sea levels, tropical cyclone intensity, and heavy precipitation during the rainy season can lead to increased inundation risks at Dawei.

Figure 25. Distribution of Projected Climate Change-related Disaster Risks in Burma. Green circle shows the dry zone, which is not of interest in this study. Thanintharyi is the southern-most region.[113]



[112] UNDP, 2011.
[113] UNDP, 2011.

Figure 26. Geographic location of Dawei (Source: Google Earth, 2013).



Potential Impacts of Climate Change on Project and Adaptation Options[114]

Due to the lack of information on historical vulnerabilities of the Dawei region and on detailed design specifications of the Dawei deep seaport and industrial estate, it is not possible to assess the potential impacts of climate change on this massive project. Since construction of the deep seaport is essential for achieving the vision of Dawei as a major logistics hub, this section provides a high-level, illustrative discussion of potential climate change impacts on the Dawei port as well as adaptation options to address such impacts.

Increased Temperature. Increase in extreme heat at Dawei (as suggested by the projected increase in average daily maximum temperature and the number of hot days) can caused paved surfaces of terminals and other port facilities to deteriorate more quickly. Structures made from metals such as handling cranes and warehouses are sensitive to temperature and will be affected by extreme heat. Warmer temperatures can also affect pests, rust, and mold, therefore increasing risks of spoilage of foods stored. Higher temperatures will also result in greater energy consumption and costs. Electricity outages during extreme heat events can spoil refrigerated goods. Hotter and drier conditions can lead to increased risk of dust explosions associated with grain handling and storage. Furthermore, heat waves pose health and safety risks for workers, limiting the amount of time they can spend outdoors and potentially causing delays in port operations and maintenance.

Adaptation options may include using pavement materials and structures that can withstand the projected higher temperatures, increasing frequency of quality checks for stored perishable goods, considering putting in

[114] U.S. CCSP, 2008; IFC, 2011; NRC, 2008; Scott et al., 2013.

place refrigeration, cooling, insulation, and ventilation systems, reviewing dust mitigation measures to prevent dust explosions, having sufficient power backup in case of electricity outages, installing energy efficient equipment, adopting energy efficient practices, and having a heat emergency preparedness and response plan.

Increased Heavy Precipitation. Dawei already receives a large amount of rainfall (over 5,000 mm per year). The increase in heavy precipitation events during the wet season coupled with sea level rise and increase in storm intensity can increase coastal flood risks at Dawei. Riverine flood risks may also increase as the project is located by the Dawei River, and connecting roads traverse other rivers as well. Flooding can weaken port structures and increase the presence of mold, damaging stored goods. Flooding can also damage or destroy electrical equipment, disrupting port operations. Channels can be blocked from debris. In addition, heavy rain can reduce visibility and impair port operations. The loading and unloading of water-sensitive goods or materials can be halted during intense precipitation events.

Adaptation options may include accounting for flood risks in port design and construction (e.g., avoiding development in low-lying areas, elevating port structures, improving port drainage, using water-resistant materials, insulating electrical equipment, designing storage to ensure perishables are located in less vulnerable areas), increasing frequency of quality checks for stored perishable goods, and establishing evacuation and business continuity plans for coastal and riverine flooding.

Sea Level Rise and Increased Tropical Cyclone Intensity. If not accounted for in the construction of the port, sea level rise can lead to temporary or permanent inundation of port facilities. According to an Economist article, an ITD executive indicated that the swampy ground at the Dawei project site will have to be raised by 2 meters to protect against sea level rise.[115] While Dawei is identified as being at low risk to tropical storms due to its geographical location, the level of risk can increase as a result of increased tropical cyclone intensity and sea level rise. Sea level rise will allow storm surge to go further inland and cause greater damage. Storm surge and direct wave action can damage port buildings, piers, wharves, berths, and other facilities. Seawater flooding will increase metal corrosion of equipment. Fast moving water can dislodge containers and other cargo from open storage areas, with floating containers potentially causing damage to port structures and equipment. During a storm event, port services will be disrupted due to limited visibility, strong wind, and heavy rainfall. Port services can be delays after the storm due to the need to clean up and repair. Storm surge can also wash debris and sediment into the shipping channels, necessitating dredging following the storm.

Adaptation options may include accounting for sea level rise and flood risks in port design and construction (see examples under Increased Heavy Precipitation), establishing evacuation and business continuity plans for coastal flooding, and properly anchoring structures and equipment (e.g., floating pier, cranes) and protecting electric equipment from flooding before the storm.

Most importantly, as the Dawei port is still in design phase, it is critical to conduct data collection and analysis to integrate climate change considerations into the port's design and construction. This can help avoid future retrofits and repairs that may be costly to implement. In addition, it will be important to increase the organizational capacity of the port to respond to extreme weather events. This can be done through awareness raising, training, and ongoing data collection, monitoring, and research.

Monitoring and Evaluation

Monitoring and evaluation will be critical to establish an ongoing understanding of how climate will impact the project. A comprehensive monitoring and evaluation plan should be done on regular intervals, during and beyond the construction phase of the project, and seek to monitor three elements of the project: (1) the overall project success, (2) environmental and social impacts, and (3) climate variables.

[115] The Economist, 2013.

At present, there are no publically available results-based monitoring and evaluation plans. The project has a diverse array of stated benefits including:

- Job creation
- Knowledge and technology transfer
- Growth of local businesses
- Strengthening of regional trade
- National economic growth and higher standard of living for Burmese citizens

For each of these benefits, it is critical to identify the causal pathway that outlines exactly how the development of the seaport leads to the stated benefit. The causal pathway can be described using a series of if-then statements which include the needed resources (inputs), the assets constructed (outputs), the results from the operations of these assets (outcomes) and the ultimate benefits (impact) . The construction of these causal pathways allow for investigation of the extent to which the project can realistically expect the anticipated benefits. In addition, it allows the development of a monitoring and evaluation framework so that each potential impact can be monitored during project implementation, and even afterwards, to assess progress in achieving the benefits.

Climate change may affect the ability of the project both to achieve its stated benefits and to mitigate adverse environmental and social impacts. Therefore it is critical that the M&E data be reviewed regularly alongside local climate change data to allow for adjustments during the project. The project M&E plan should include routine measurements for temperature, precipitation, and sea level, as well as documenting the frequency and intensity of extreme weather events. By establishing regular monitoring of climate variables alongside indicators of operational performance, ITD and the Burmese government will have an important baseline to understand the complex interaction of climate and project outcomes over time.

Resources

Asian Development Bank. 2012. Addressing Climate Change and Migration in Asia and the Pacific. Manila, Philippines.

Aung, Myo. 2012. Local Action, Central Policy, and the Law: The Dawei Deep Sea Port and Special Economic Zone. In: Land, Water, Rights: Voices from the Tibetan Plateau to the Mekong Delta. EarthRights International. A collection of reports by students of the EarthRights School Mekong. Chiang Mai, Thailand.

Baroang, Kye. 2013. Background Paper No. 1 – Burma Bio-Physical Characterization: Summary Findings and Issues to Explore. Center on Globalization and Sustainable Development, Earth Institute at Columbia University. Prepared for USAID/Burma under contract GDG-A-02-000921-0 to Michigan State University as background for the "Strategic Agricultural Sector and Food Security Diagnostic for Burma". Available at: http://fsg.afre.msu.edu/Burma/Burma_branded_Background_paper_1_Biophysical_Characterization_May2013.pdf. Accessed August 21, 2013.

Bloomberg. 2012. Myanmar Questions Italian-Thai's Resource for Giant Dawei Project. The Nation. May 4, 2012. Available at: http://www.nationmultimedia.com/business/Myanmar-questions-Italian-Thais-resource-for-giant-30181279.html. Accessed August 21, 2013.

Chachavalpongpun, Pavin. 2011. Dawei Port: Thailand's Megaproject in Burma. Global Asia: A Journal of the East Asia Foundation. Available at: http://www.globalasia.org/l.php?c=e448. Accessed August 21, 2013.

Dawei Project Watch. 2012. No Rights to Know: The Collective Voices of Local People from the Dawei Special Economic Zone. Available at: http://www.burmalibrary.org/docs13/N0_Rights_to_Know-Dawei-op75-50.pdf. Accessed August 21, 2013.

Deed, Stuart. 2012. How will the Dawei Project Benefit Myanmar? Myanmar Times. November 5, 2012. Available at: http://mmtimes.com/index.php/opinion/2883-how-will-the-dawei-project-benefit-Burma.html?start=1. Accessed August 21, 2013.

Ecological Alert and Recovery of Thailand (EARTH), Healthy Public Policy Foundation of Thailand, and Towards Ecological Recovery and Regional Alliance (TERRA). 2012. Dawei: Points of Concerns. Available at: http://www.inebnetwork.org/attachments/article/387/Dawei_Concerns_August2012_small.pdf. Accessed August 21, 2013.

Food and Agriculture Organization (FAO). 2009. Digital Agricultural Atlas of the Union of Myanmar. Rainfall (Annual Average). Available at: http://dwms.fao.org/atlases/myanmar/atlas_en.htm. Accessed September 13, 2013.

U.S. Federal Highway Administration (FHWA). 2012. Gulf Coast Study Phase 2: Sensitivity Matrix. Available at: http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/phase2_task2/sensitivity_matrix. Accessed August 21, 2013.

Inter-governmental Panel on Climate Change (IPCC). 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

International Finance Corporation. 2011. Climate Risk and Business: Ports. Terminal Marítimo Muelles el Bosque, Cartagena, Colombia.

Italian-Thai Development Public Company Limited (ITD). 2011. Annual Report 2011.

Italian-Thai Development Public Company Limited (ITD). 2012. Annual Report 2012.

Italian-Thai Development Public Company Limited (ITD). 2013a. Dawei Deep Seaport and Industrial Estate Development Project: May 2013 Presentation. Available at: http://www.daweidevelopment.com/index.php/en/downloads. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013b. Dawei Project: Introduction. Available at: http://www.daweidevelopment.com/index.php/en/introduction. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013c. Dawei Special Economic Zone. Available at: http://daweidevelopment.com/index.php/en/dsez-law. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013d. Clean Coal Technology to be Used in Dawei Power Plant. August 1, 2013. Available at: http://daweidevelopment.com/index.php/en/international-news/391-clean-coal-technology-to-be-used-in-dawei-power-plant. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013e. Project Update: Work Progress July 2013. Available at: http://daweidevelopment.com/index.php/project-update. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013f. Key Highlight of Main Infrastructure. Available at: http://www.daweidevelopment.com/index.php/en/why-invest-in-dawei/key-highlight-of-main-infrastructure. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013g. Project Development Plan. Available at: http://www.daweidevelopment.com/index.php/en/dawei-project/project-development-plan-. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013h. Environmental & Social Concerns. Available at: http://www.daweidevelopment.com/index.php/en/dawei-project/environmental-a-social-concerns. Accessed August 21, 2013.

Italian-Thai Development Public Company Limited (ITD). 2013i. Corporate Social Responsibility Update: July 2013. Available at: http://daweidevelopment.com/Downloads/CSR%20July%202013%20Newsletter.pdf. Accessed August 21, 2013.

Maipanich, Nongnapas. 2013. Transport Agency in Urgent Review of Dawei. The Nation. February 12, 2013. Available at: http://www.nationmultimedia.com/business/Transport-agency-in-urgent-review-of-Dawei-30199837.html. Accessed August 21, 2013.

National News Bureau of Thailand. 2013. Thailand & Myanmar Create Company to Invest in Dawei Project. June 18, 2013. Available at: http://thainews.prd.go.th/centerweb/newsen/NewsDetail?NT01_NewsID=WNECO5606180010001. Accessed August 21, 2013.

National Research Council (NRC). 2008. Transportation Research Board Special Report 290: Potential Impacts of Climate Change on U.S. Transportation.

Ng, Connie. 2013. Burma and the Road Forward: Lessons from Next Door and Possible Avenues Towards Constitutional and Democratic Development. *Santa Clara Law Review* 53(1): 267– 299.

Paung Ku and Transnational Institute. 2012. Land Grabbing in Dawei (Myanmar/Burma): A (Inter)National Human Rights Concern. Available at: http://www.tni.org/sites/www.tni.org/files/download/dawei_land_grab.pdf. Accessed August 21, 2013.

Regional Integrated Multi-Hazard Early Warning Systems (RIMES). 2011. Managing Climate Change Risks for Food Security in Myanmar. Available at: http://www.foodsec.org/fileadmin/user_upload/eufaofsi4dm/docs/Myanamr%20-%20RIMES%20(2011-07)%20Managing%20Climate%20Change%20Risks%20for%20Food%20Security.pdf. Accessed August 21, 2013.

Saw Eh Na. 2013. Thai Surveyors Fail to Gain Villagers' Trust. Karen News. Available at: http://karennews.org/2013/05/thai-surveyors-fail-to-gain-villagers-trust.html/. Accessed August 21, 2013.

Scott, Helen, Darryn McEvoy, Prem Chhetri, Fatima Basic, and Jane Mullett. 2013. Climate change adaptation guidelines for ports. Report series: Enhancing the resilience of seaports to a changing climate. Australia National Climate Change Adaptation Research Facility and RMIT University. Available at: http://global-cities.info/wp-content/uploads/2013/03/Climate-resilient-ports-series-Adaptation-Guidelines.pdf.

TEAM Consulting Engineering and Management Co., Ltd. 2013. Tanintharyi Hydropower Project. Available at: http://www.teamgroup.co.th/index.php/en/credentials/projects/water-resources-a-hydropower/278-tanintharyi-hydropower-project-republic-of-the-union-of-Burma.html. Accessed August 21, 2013.

Thabchumpon, Naruemon, Carl Middleton, and Zaw Aung. 2012. Development, Democracy, and Human Security in Myanmar: A Case Study of the Dawei Special Economic Zone. Second International Conference on International Relations and Development (ICIRD). Available at: http://www.icird.org/2012/files/papers/Naruemon%20Thabchumpon,%20Carl%20Middleton%20and%20Zaw%20Aung2.pdf. Accessed August 21, 2013.

Thakhin, Thukha. 2011. Dawei Development Project is Creating the Negative Impacts of Land Confiscation, Changing Lifestyles, and Lack of Livelihoods for Local People East and West of Dawei. In: Where the Change Has Yet to Reach: Exposing Ongoing Earth Rights Abuses in Burma (Myanmar). Voices from the EarthRights School Burma 2010-11. EarthRights International. Chiang Mai, Thailand.

The Economist. 2013. Build It and They Might Come. August 3, 2013. Available at: http://www.economist.com/news/asia/21582554-planned-thai-mega-project-myanmar-runs-difficulty-build-it-and-they-might-come. Accessed August 21, 2013.

The New York Times. 2010. An Industrial Project That Could Change Myanmar. Available at: http://www.nytimes.com/2010/11/27/world/asia/27iht-myanmar.html?pagewanted=all. Accessed August 21, 2013.

U Tin Than. 2012. Can Myanmar Biodiversity Survive the Swell of Political Transformation? Institute for Global Environmental Strategies. Monthly Asian Focus. Available at: http://www.iges.or.jp/en/archive/Asianfocus/asianfocus201201.html. Accessed August 21, 2013.

United Nations Development Programme (UNDP). 2011. Proposal for Myanmar: Addressing Climate Change Risks on Water Resources and Food Security in the Dry Zone of Myanmar. Submitted to the Adaptation Fund Board. December 2, 2011. Available at: https://www.adaptation-fund.org/sites/default/files/AFB.PPRC_.7.12%20Proposal%20for%20Burma.pdf.

United Nations Framework Convention on Climate Change (UNFCCC). 2013. Non-Annex I National Communications. Available at: http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php. Accessed August 21, 2013.

United States Climate Change Science Program (U.S. CCSP). 2008. SAP 4.7: Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I.

Wheeler, David. 2011. Quantifying Vulnerability to Climate Change: Implications for Adaptation Assistance. Center for Global Development. Working Paper 240.

Wildlife Conservation Society of Thailand. 2010. Restoring Tenasserim Corridor for Living Connectivity. Available at: http://www.wcsthailand.org/main/downloads/Corridor/RestoringTenasserim-eng.pdf. Accessed August 21, 2013.

Wildlife Conservation Society of Thailand. 2013. The Tenasserim Western Forest Complex Corridor. Available at: http://www.wcsthailand.org/english/corridor_project. Accessed August 21, 2013.

World Bank. 2013. Climate Change Knowledge Portal: Myanmar. Available at: http://sdwebx.worldbank.org/climateportal/index.cfm. Accessed August 21, 2013.

Yeni. 2011. Port Project Raises Concerns about Rights, Environment. The Irrawaddy. January 12, 2011. Available at: http://www2.irrawaddy.org/article.php?art_id=20508. Accessed August 21, 2013.

Melamchi Water Supply Project, Nepal

Construction of the water diversion tunnel in the Melamchi Water Supply Project (Source: MWSDB, 2012).

Table of Contents

List of Figures

List of Tables

Project Background

INTRODUCTION

Kathmandu Valley is Nepal's largest urban economy and has experienced chronic water shortages, affecting the environment, human health, and economic capacity. In some cases, residents in Kathmandu Valley have resorted to relying on increasingly polluted shallow wells and mining for deep aquifers. Water shortage and poor water quality have a significant impact on public health, particularly on the health of the poor. Population expansion is exacerbating the water supply issue; Kathmandu district experienced a 61.2% decadal population growth from 2001, with more than 1.7 million residents by 2011.[1]

Figure 1: Project Location

The Melamchi Water Supply Project (MWSP) is designed to help alleviate shortage of potable water in Kathmandu Valley. MWSP will divert about 170 million liters of water per day of fresh water from the Melamchi River in Sindhupalchowk district to Kathmandu Valley (see Figure 1 for project location).

MWSP commenced in December 2000 but a series of financial and performance challenges have delayed the project construction. The first major delay occurred when three international development partners withdrew financing for the project.

In 2008, the project was restructured into two sub-projects:

> **Sub-Project 1: Melamchi River Water Diversion** covers all water diversion project activities in Melamchi Valley including construction of the Water Diversion Tunnel (WDT) and Water Treatment Plant.
>
> **Sub-Project 2: Kathmandu Valley Water Supply and Sanitation** is comprised of water distribution activities in Kathmandu Valley. Improvements to the distribution network are expected to reduce water losses and improve service delivery to consumers by enhancing the supply and water pressure.

The total project (including the two subprojects) was anticipated to be completed by September 2013 for a cost of $317.3 million.

TIMELINE

December 2000: Asian Development Bank (ADB) approved Loan 1820-NEP for MWSP. ADB shouldered the largest financing share for the project among several international development partners.[2]

June 2002: The World Bank decided to refrain from funding the project.[3] World Bank had proposed a Private Sector Participation financing plan to manage water services for the project but the private lease failed to attract interest from potential bidders.

December 2004: Kathmandu Valley Water Services Sector Development Program was established to support reforms and institutional development in the water services sector by engaging private sector participation.[4]

---

[1] CBS, 2012.
[2] MWSDB, 2012.
[3] MWSDB, 2012.

2005-2006: Following the lead of the World Bank, the Norwegian Agency for Development and Swedish International Development Cooperation Agency (SIDA) also decided to withdraw funding from the project.[5]

2007: Government of Nepal and the project's funding partners changed the scopes of project implementation arrangement by splitting the MWSP into the two distinct sub-projects.[6]

February 2009: A contract for construction of the water diversion tunnel was awarded.[7] The intended completion date was September 2013.

April 2010: Physical works on the water diversion tunnel commenced.[8]

September 2012: Physical works on the water diversion tunnel was terminated due to the unsatisfactory performance of the Contractor.[9] The tunnel excavation was 22% complete at the time of the termination.

July 2013: A second contract for construction of the water diversion tunnel was signed.[10] Physical works on the water diversion tunnel has resumed. The contract is expected to be completed by 2016. Additionally, MWSDB signed the contract to begin construction of the water treatment plant.

---

[4] MWSDB, 2012.
[5] ADB, 2008a.
[6] MWSDB, 2012.
[7] MWSDB, 2012.
[8] MWSDB, 2012.
[9] MWSDB, 2012.
[10] ADB, 2013.

FUNDING[11]

The original project financing was spread across nine organizations. However, three of the co-financing development partners – the World Bank, Norwegian Agency for Development, and SIDA withdrew support for the project and stalled implementation. The withdrawal resulted in a $133 million shortfall, the need to restructure the financing, and a delay in project implementation.

The original and restructured financing plans are outlined in Table 1.

Table 1: Original and Restructured Financing Plans for Melamchi Water Supply Project (MWSDB, 2012). All figures are in $US millions.

Source of Funding	Finance Plan	
	Original	**Restructured**
Asian Development Bank (ADB)	$120m	$137m
World Bank	$80m	~~$0~~
Japan Bank for International Cooperation (JBIC)	$52m	$47.5m
Norwegian Agency for Development Cooperation	$28m	~~$0~~
Swedish International Development Cooperation Agency (Sida)	$25m	~~$0~~
Japan International Cooperation Agency (JICA)	$18m	$18m
Organization of Petroleum Exporting Countries Fund for International Development (OFID/OPEC)	$14m	$13.7m
Nordic Development Fund (NDF)	$9m	$10.5m
Government of Nepal (GoN)	$118m	$90.6m
Total	**$464m**	**$317.3m**

[11] ADB, 2013.

PROJECT LOCATION

The project is located in Kathmandu and Sindhupalchowk Districts in central Nepal (see Figure 2).[12] The water intake site is located in the upper part of the Melamchi River basin, near Dorin and Ghwakang Village. It is part of the Melamchi Valley (Figure 3), which is a typical narrow, v-shaped, rocky, and steep Himalayan Valley. The water intake site lies in the lower section of a rocky river gorge with sheer cliffs. The Melamchi River Water Diversion tunnel will pass through at least four major faults. It is suspected that one of the fault lines, the Gyalthum fault, bifurcates the tunnel route. These faults and deep weathering of local rock formations can affect tunnel stability and cause construction difficulties. In addition, erosion and land instability are of concern as heavy rain can wash away the sandy top soils in the Melamchi Valley.[13]

Figure 2: Map of Nepal's Districts with Project Location Highlighted (Adapted from bigfootprint.org, 2013)

The water intake draws from the Melamchi River. Snowmelt and rainfall are the two main sources of water for the river.[14] Langtang National Park, a protected mountain area, is part of the watershed and minimizes erosion and sedimentation in the upper half of the Melamchi Valley. Except for its buffer zone, the Langtang National Park is not affected by the Melamchi Water Supply Project.

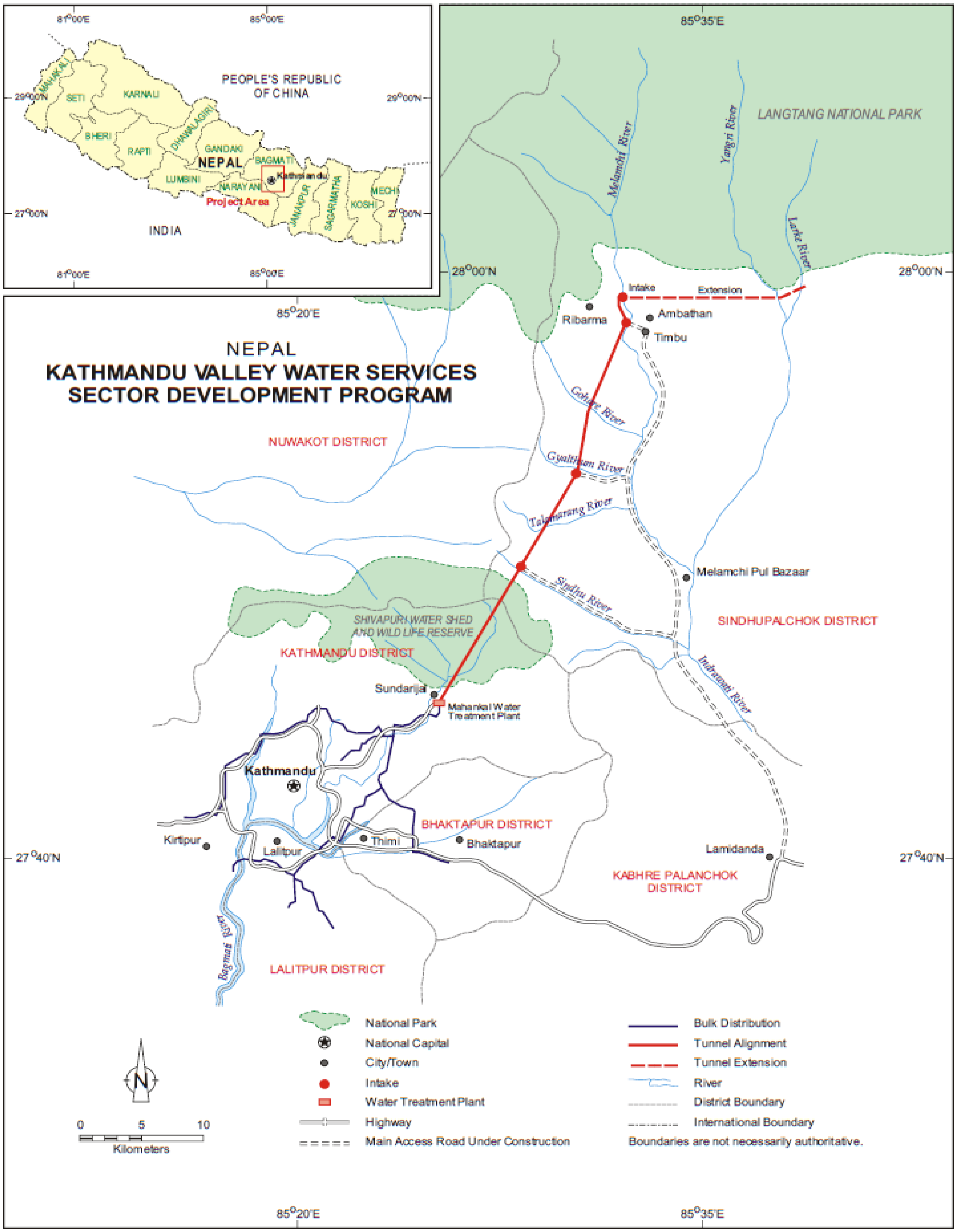
[12] MWSDB, 2012.
[13] ADB, 2000.
[14] ADB, 2000.

The project area stretches to the Melamchi River outlet at Sundarijal, about 14 km north-east of Kathmandu city.[15] The water treatment plant will be located in Sundarijal. See Figure 4 for information about the project location.

Figure 3: The Melamchi River located in Melamchi Valley[16]

[15] MWSDB, 2012.
[16] MWSDB, 2012.

Figure 4: Project location[17]



[17] ADB, 2008a

PROJECT ASSETS AND OPERATIONS

The Ministry of Physical Planning and Works (MPPW) is the executive agency for the project and the Melamchi Water Supply Development Board (MWSDB) is the implementing agency, an independent body that was formed specifically for this project. The MPPW supervises the MWSDB and reports to the Government of Nepal and ADB.

Sub-Project 1: Melamchi River Water Diversion[18]

The Melamchi Water Diversion Scheme is designed to carry out about 170 million liters per day of water through a 26.5 km gravity water conveyance tunnel from the Melamchi River into Kathmandu Valley. The project area will be excavated through drill and blast method and the tunnel and intake structures will be installed. The tunnel can be accessed through several entrances, or adits. The project will construct, operate, and manage camp site offices at Melamchi Pool Bazar (the main camp), Ambathan Adit, Gyalthum Adit, Sindhu Adit and Sundarijal Adit (see the intakes marked by red circles in Figure 4).

The project will construct a water treatment plant to process raw water from the Melamchi River brought in by the diversion tunnel. Water from the various intakes is carried by the diversion tunnel into the water treatment plant, where it will be treated to potable standards in compliance with current World Health Organization Guidelines. The water treatment plant will have an initial capacity of at least 170 million liters per day and expandable to about 510 million liters per day. The plant and ancillary pipes and roads will be constructed in three phases. The plant will consist of a reception chamber, mini-hydro power generation, distribution chamber, flocculation basins, sedimentation basins, filtration units, pipe gallery, clear water reservoir, sludge lagoons, Central Building Complex comprising chemical facilities, maintenance and administration facilities, and on-site pipework.

The water treatment plant is located near Mahankal, a village by the Bagmati River about 12 km northeast of Kathmandu city (see Figure 4). The plant is situated at an elevation of approximately 1400 m so that the treated water can be distributed by gravity to existing and proposed reservoirs in the Kathmandu Valley. The proposed treatment process includes pre-treatment, sedimentation, lime dosing, rapid sand filtration, and disinfection.

The subproject also includes construction, maintenance, and management of access roads connecting the project's sites and facilities. About 43 km of access roads will be constructed and about 29 km of road will be upgraded. The road upgrading and construction will cut hillsides and alter slope, thus affecting local stability. Stabilization techniques will be used to mitigate these impacts.

Subproject II: Kathmandu Valley Water Supply and Sanitation

The Kathmandu Valley Water Supply and Sanitation Subproject is designed to rehabilitate and improve the water supply and distribution networks. It will construct a bulk distribution system consisting of service reservoirs and bulk water supply pipelines leading from the water treatment plant to the reservoirs. It will also rehabilitate and improve the existing distribution networks including intakes, transmission lines, water treatment plants, and service reservoirs. The subproject will improve the wastewater system in a phased manner. A shallow ground water well field will be developed at Manohara within the Kathmandu Valley to extract, treat, and distribute about 15 million liters per day of water in dry season and 25 million liters per day of water in wet season.[19] Additionally, the subproject consists of institutional reforms, such as changes to the water tariff structure to make it more equitable. [20] This will help alleviate the potential negative impact of increased water rates on poorer population in Kathmandu Valley.[21]

[18] MWSDB, 2012.
[19] ADB, 2008b.
[20] MWSDB, 2012.
[21] ADB, 2000.

Environmental and Social Impacts

Environmental Impacts

The Environmental Impact Assessment of the project was completed in 2000[22] and an Environmental Management Plan was developed and approved for implementation in 2001. After the project was restructured into two sub-projects in 2008, two updated Environmental Management Plans were developed, one for each Sub-project. In addition to discussing potential environmental impacts, the updated Environmental Management Plans incorporated impacts that were observed during project implementation between 2001 and 2008. Some of the main environmental impacts are summarized below. See the Environmental Impact Assessment (2000)[23] and the two updated Environmental Management Plans (2008)[24,25] for a full discussion of the project's major environmental impacts.

Water Diversion Scheme [26]

According to the Environmental Management Plan for Sub-project 1 (2008), construction and use of the access roads, quarry, and borrow pits (where material such as soil, gravel or sand is dug for use at another site) will affect stability and potentially cause erosion and landslides. The implementation phase between 2001 and 2008 identified 42 sites prone to erosion. The construction of roads, quarry, and borrow pits can also cause siltation and sedimentation, degradation of agricultural land, disruption of 11 existing irrigation canals in the Melamchi Valley, and increase in dust and noise levels. Change in the Melamchi river course can result from the excavation of boulders from the river channel. In addition, road construction will result in spoil materials (excavation wastes consisting mostly of rock wastes) and liquid wastes (e.g., liquids used for dust suppression). The disposal of these wastes and leakage of oil and lubricants from road construction can cause water pollution. However, water monitoring during the road construction showed no major water pollution issues as of 2008.

The construction of the tunnel will likely cause slope instability and generate about 460,000 m^3 of tunnel muck that may need 1.95 ha of land for disposal. The disposal of oil and slurry from tunnel construction can cause pollution and turbidity in the Melamchi River. The impacts on water quality due to the tunnel construction were unknown as of 2008 as this part of the project was not yet initiated.

The 2000 Environmental Impacts Assessment predicted that 2,815 trees would be removed for the Water Diversion Scheme and the Water Treatment Plan sites, but monitoring records during construction showed that as of 2008, site clearance for road construction alone resulted in the removal of 17,347 trees.

The construction of the tunnel and intake structure can also lead to habitat destruction along the river course, destroy fish breeding sites, trap fish in the intake structure, block migratory routes for fish and mammals, and increase illegal poaching. During operation, the tunnel will divert a flow of 1.97 m^3/s from the river, which will impact the downstream river hydrology, particularly in the dry months from January to June (the dry season is from December through May). The reduced flow will likely affect fisheries downstream.

Water Treatment Plant [27]

The construction of the water treatment plant can lead to runoff and erosion due to digging and disposal of spoil materials. During operation, the plant is expected to generate about 15,330 m^3 of sludge per year. As aluminum-

[22] ADB, 2000.
[23] ADB, 2000.
[24] ADB, 2008b.
[25] ADB, 2008c.
[26] ADB, 2008b.
[27] ADB, 2008b.

based chemicals will be used as part of the water cleaning process[28], the sludge will contain high amounts of aluminum, which will cause harm to plants in acidic soils. If not adequately and safely disposed, this sludge will present a major environmental hazard.

Water Distribution Structures [29]

The impacts of water distribution network construction are similar to the impacts from the road and tunnel construction. Impacts include soil erosion, landslides, siltation, sedimentation, dust and noise, impacts on the river hydrology, and impacts on water quality from disposal of construction wastes. Most of the construction and improvement work of the water distribution network will occur in urban areas, with limited impacts on biodiversity.

Social Impacts

As the project will alleviate the chronic water shortage in the Kathmandu Valley, the primary beneficiaries of the project are the 1.4 million people living there. The project will however result in several negative impacts on the communities in the Melamchi Valley.[30]

Sub-project 1 requires the acquisition of 66 hectares of private land from 1,550 landowners and affected 130 houses and structures in the districts of Sindhupalchock, Kaverpalonchock, and Kathmandu. A total of 4,464 people in 795 households will be temporarily affected by the construction of the sub-project, mostly by the loss of trees and crops. Many of the affect communities are vulnerable ethnic minorities.[31] The project will cause reduced water flow downstream, affecting several water mills and nearly 200 people of 34 families who are engaged in fishing activities.[32]

Potential indirect adverse social impacts from Sub-project 1 and Sub-project 2 may include social disruption caused by the influx of outside workers. The influx of workers may cause loss of employment or income due to changes in the economic structures, increased sexually transmitted diseases, increased sex trafficking, and child labor. [33] Outside workers will come with their immediate family members, causing increase in population and putting pressure on the limited local resources. Traffic congestion can result from an estimated 90 heavy vehicles that are used daily for transport of construction materials.[34,35]

Nonetheless, the project infrastructure construction and the implementation of mitigation measures through the Social Uplift Program can bring benefits to the 70,000 people in the project area in the Melamchi Valley. The access roads will improve access to Kathmandu and within the Melamchi Valley and can increase incomes through the expanded market. The investments in energy for project construction will increase the availability of electric power. The Social Uplift Program will create several benefits, including upgraded skills and increased incomes, increased adult literacy rates, increased number of children of better education, reduced workload for women, increased gender awareness, increased health and family planning awareness and improved health conditions, especially for women and children, and reduced incidence of trafficking of girls.[36]

[28] WHO, 1998.
[29] ADB, 2008c.
[30] ADB, 2000.
[31] ADB, 2008d.
[32] ADB, 2008b.
[33] ADB, 2000.
[34] ADB, 2008b.
[35] ADB, 2008c.
[36] ADB, 2000.

ENVIRONMENTAL AND SOCIAL COMMITMENTS

The project is implementing environmental and social monitoring and management under the Social Uplift Program. It will conduct a third party monitoring of the activities and prepare a monthly, quarterly, and annual progress report on the environmental and social impacts of the project.[37]

Environmental Commitments[38, 39]

The Environmental Management Plans for Sub-project 1 and Sub-project 2 detail the mitigation measures to address the project's environmental impacts. They also include a work plan to implement the mitigation measures, a monitoring program, and mechanism for feedback and adjustment. Furthermore, the Plans are being actively monitored and adjusted.[40] Some examples of the mitigation measures are provided below; see the Environmental Management Plans[41] for the full list of mitigation measures.

To reduce soil erosion, sedimentation, and slope instability, the project will adopt cut-and-fill principles when constructing the tunnel and road. It will also develop a drainage plan, minimize vegetation clearance, avoid stockpiling of spoil materials in the construction site, protect off-site vegetation, and revegetate barren area around the project site. In addition, the project will prohibit quarry operation within the wet channel of river and prevent excessive excavation. It will avoid construction work of the roads, tunnel, and water treatment plant during the monsoon season. When constructing the water treatment plant, the project will adequately dispose spoil materials and use spoil materials in land filling to cover waste materials from the water treatment plant.

To address change in environmental flow and water quality, the project will release a flow of 0.4 m^3/s during operation. This amount of water, along with the tributary flow, seepage, and groundwater is estimated to be adequate for downstream ecology and other water requirements. Additionally, the project will prevent disposal of waste from workers' camping and construction activities. It will also canalize the intercepting surface run-off from upland villages and strip or cap the topsoil layer of the reservoir bed prior to inundation to maintain water quality at the reservoir.

To address soil quality change, the project will stockpile topsoil for reuse, dispose toxic sludge together with liquid waste in a safe place, and carry out off-site vegetation protection. It will dispose of tunnel muck on a wide flood plain. After spreading and compaction of topsoil, this area can be developed into an agricultural land. Sludge from the water treatment plant will be properly disposed through the process of land filling.

To address change in the biological environment, the project will carry out compensatory planting at the rate of five trees for every tree cleared in the project area and compensate private owners and community forests. It will prohibit construction workers from hunting, provide them with groceries for food, reduce noise levels to reduce disturbance to wildlife, and establish an environmental conservation education program for the local communities and schools. In order to protect aquatic life, the project will release an environmental flow of 0.4 m^3/s during all times, establish a trout hatchery for fish stocking at Timbu, prohibit fishing, and install fish screening devices at the intake point.

Social Commitments

The objectives of the Resettlement Action Plan (RAP) are to avoid involuntary resettlement wherever feasible and ensure that the livelihoods of project-affected households are restored. The MWSDB prepared a

[37] MWSDB, 2012.
[38] ADB, 2008b.
[39] ADB, 2008c.
[40] ADB, 2012a and 2012b.
[41] ADB, 2008b and 2008c.

Resettlement Policy Framework for Subproject 1.[42] Compensation and mitigation measures include: compensation for acquisition of land, mitigation for the loss of water due to diversion to Melamchi River, employment restoration, and a job creation plan.

Subproject 1 will also include a Social Uplift Program which will include a) buffer zone development, b) rural electrification, c) health, d) education, and e) income generation/community development.[43] The buffer zone is designed to preserve the Langtang National Park environment from population influx. The project will also develop a Health Plan for improving and upgrading existing health facilities and health care in the Melamchi Valley. The Social Uplift Program will assist in the development and upgrading of education through initiatives including building or upgrading of physical facilities, implementation of school sanitation programs, training of teachers, provision of grants and scholarships, and implementation of adult literacy programs. The program will provide guidance and funding to promote income generation and community development activities through capacity building at the local level. Lastly, as part of the program, the project will launch a rural electrification program in parts of the Melamchi Valley.

The project will develop a NGO participation plan. NGOs in the Melamchi and Kathmandu valleys will act as facilitators to help implement the Social Uplift Program.[44]

ADHERENCE TO ENVIRONMENTAL AND SOCIAL COMMITMENTS

Environmental commitments

A third party, Integrated Consultants Nepal (P) Ltd. and Consolidated Management Services (P) Ltd., prepared 2012 Annual Environmental and Social Monitoring Report for Sub-project 1 and Sub-project 2. The two reports present results from monitoring of air quality, noise level, discharge, fish pollution, diversity, and other parameters.

Sub-project 1

The 2012 Annual Environmental and Social Monitoring Report for Sub-project 1 stated that the average noise level outside the tunnel exceeded the threshold limit (75 dBA) in several months in 2012. Exposure to high noise level for over eight hours can be harmful to workers. Water quality monitoring showed that turbidity, pH, manganese, and iron were high for several sites at Melamchi, but the rest of the parameters were within the World Health Organization guideline value. The tunnel effluent test showed that few parameters exceeded the generic standard that can be discharged into inland water bodies. Nevertheless, the report recommended oxidizing the effluent before discharging and installing aeration system in every settling chamber. The report indicated very few illegal fishing activities were noticed during fish survey, which was potentially due to the frequent patrol of the police and army personnel. In addition, the project is implementing afforestation and reforestation as promised. It established a seedling nursery and had distributed a total of 13,604 seedlings to seven villages within the zone that is directly affected by the project.[45]

Sub-project 2

The 2012 Annual Environmental and Social Monitoring Report for Sub-project 2 discussed the problems the project encountered during construction and improvement of the water distribution network, the demands of local communities, and the mitigation measures that the project was taking or planned to take. For example, laying of the transmission pipeline segment from Sainbu Reservoir to Nakhu Bridge was delayed due to opposition by the Sainbu local community. The locals of Sainbu were concerned that distributing the water from

[42] ADB, 2008d.
[43] MWSDB, 2012.
[44] ADB, 2000.
[45] ADB, 2012a.

their source to others can result in water scarcity for them and demanded to be guaranteed first access to the water. The project was conducting public consultation with the community to address this issue. See the Monitoring Report for other problems and mitigation measures being taken or planned.[46]

Social commitments

The land acquisition process is completed and resettlement monitoring and reporting is ongoing.[47] The owners of a total of 130 houses and structures in the project area have been displaced, resettled, and compensated.[48] According to the 2012 Annual Environmental and Social Monitoring Report, 25 cases of grievances were filed in 2012, most of which were related to compensation. The Annual Monitoring Report stated that most of the cases have been resolved with extensive consultation with the affected households. Some cases were still being addressed. For example, the local people residing upstream of Sindhu Tunnel and above the Gyalthum Adit Tunnel submitted complaints that the blasting work from tunnel and road construction caused their houses to crack. The project had conducted inspection of the cracked houses and submitted the results to the MWSDB. It would carry out analysis to determine whether the crack was due to blasting activities and provide compensation if this was the case.[49] Additionally, activities to build strong livelihoods, as part of the Resettlement Plan in Subproject 1, are underway and include: construction of health centers and provision of essential drugs; construction of school buildings and provision of educational kits to schools; and development of a forest nursery in Timbu.[50]

Background on Climate Change and Water Supply Projects

Climate patterns impact both water quality and supply. Temperature increases, precipitation changes, prolonged drought, and sea level rise will have impacts ranging from evaporation, decreased supply (from changes in precipitation and snowmelt), increased sediment and pathogen loading, and more frequent and severe algal blooms. Table 2 provides an overview of how climate change may impact water supply, treatment, and storage and distribution. While these impacts are possible, not all are likely given the design and conditions associated with the Melamchi project.

Table 2: Examples of Potential Climate Change Impacts on Potable Water Infrastructure and Services (USAID, 2013)

	Water Supply	Water Treatment	Water Storage and Distribution
Temperature Increase	◆ Reduced capacity for existing infrastructure (pumps, pipes, storage and treatment facilities) to meet increased demands ◆ Decreased water quality increasing likelihood that existing treatment infrastructure is insufficient	◆ Increased water treatment requirements and costs to address lower water quality (e.g. increased algal blooms and bacterial and fungal content)	◆ Increased storage capacity requirements due to increased demand ◆ Increased water losses during storage ◆ Decreases in water quality during storage and distribution
Increased Intensity of Precipitation and Storm	◆ Increased turbidity loading in reservoirs, due to greater runoff	◆ Lower treatment efficiency due to rapidly changing water quality ◆ Inundation of treatment facilities	◆ Additional storage facilities needed to capture water during short, high intensity storm events

46 ADB, 2012b.
47 ADB, 2013.
48 ADB, 2008d.
49 ADB, 2012a.
50 ADB, 2013.

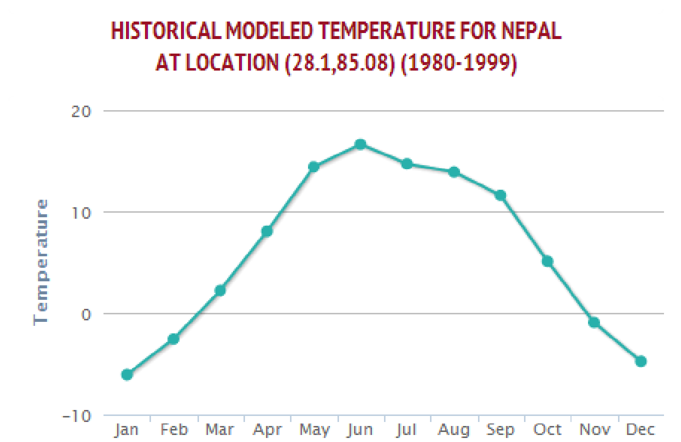
Events	◆ Less groundwater recharge due to faster runoff ◆ Damage to or inundation of infrastructure	during storm events ◆ Loss of power disrupting treatment operations ◆ Damage to water treatment facilities and distribution networks	◆ Greater need to ensure distribution system integrity, to minimize inflow of contaminated waters during storm events ◆ Increased contamination of wells from contaminated runoff
Prolonged Drought	◆ Need for additional sources of water and associate conveyance, storage, and treatment infrastructure, to respond to short- and long-term droughts	◆ Increased water treatment costs and requirements to address lower water quality (e.g., higher pollutant concentrations due to reduced dilution)	◆ Need for additional water storage to address drought periods ◆ Need to reduce water losses, and implement water conservation ◆ Need for deeper wells to reach lower water tables ◆ Increased cost and energy requirements to distribute water from new sources
Sea Level Rise	◆ Saltwater intrusion of freshwater supplies	◆ Inundation of low-lying treatment facilities and wells	◆ Need for additional water storage to replace wells impacted by saltwater intrusion

Local Conditions

CURRENT LOCAL CLIMATE

Nepal's climate is influenced by the Himalayan mountain range and the yearly South Asian monsoon. There are four distinct seasons: pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November), and winter (December-February).[51] The upper and middle parts of Melamchi Valley are characterized by temperate and sub-tropical climates; the lower region is tropical. The Melamchi Valley is located in the Central Region of Nepal.

Figure 5: Historical modeled monthly average temperature near the Melamchi Valley (World Bank, 2013).



Temperature

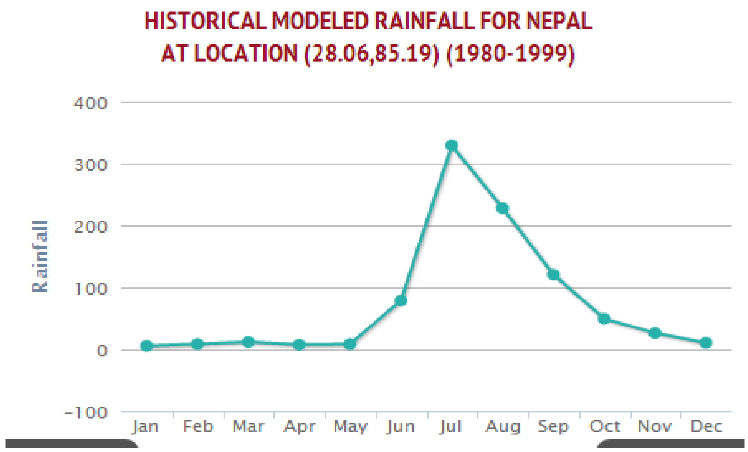
The winter season in Nepal is the coldest and the early monsoon period is the warmest. From 1980-1999, the average temperature in the Melamchi Valley region of Nepal was 6.02°C, with average monthly temperatures in the winter as low as negative 6.07°C in January and as high as 16.62°C in June.[52] See Figure 5 for average monthly temperatures.

[51] Ministry of Environment, 2010.
[52] World Bank, 2013.

Precipitation

Average rainfall is approximately 1800mm and the monsoon rain is most abundant in the east, which includes the Melamchi Valley.[53] The Kathmandu Valley is an area characterized by some of the highest rainfall in the country. Heavy rainfall in the Melamchi Valley occurs during the monsoon rains in June, July, and August.[54] Monthly rainfall during the dry season (December through May) is extremely limited, with monthly averages ranging from 5.54mm in January to 11.83mm in March. The peak historical rainfall occurs in July, with a monthly average of 329mm from 1980-1999 (see Figure 6).[55]

Figure 6: Historical modeled monthly average precipitation near the Melamchi Valley (World Bank, 2013).



Streamflow

Melamchi River originates at Jugal Himal at an elevation of 5,875 m. Rainfall and snowmelt are the two main sources of water for the River. The River runs 41 km, flowing southward and widening downstream. The average annual flow is 9.7m^3/s. The maximum flow is 289 m^3 /s in August. During the dry period, the flow decreases with the tributaries contributing a flow of 1.01m^3/s.[56]

OBSERVED CLIMATE VARIABILITY AND CHANGE

Temperature

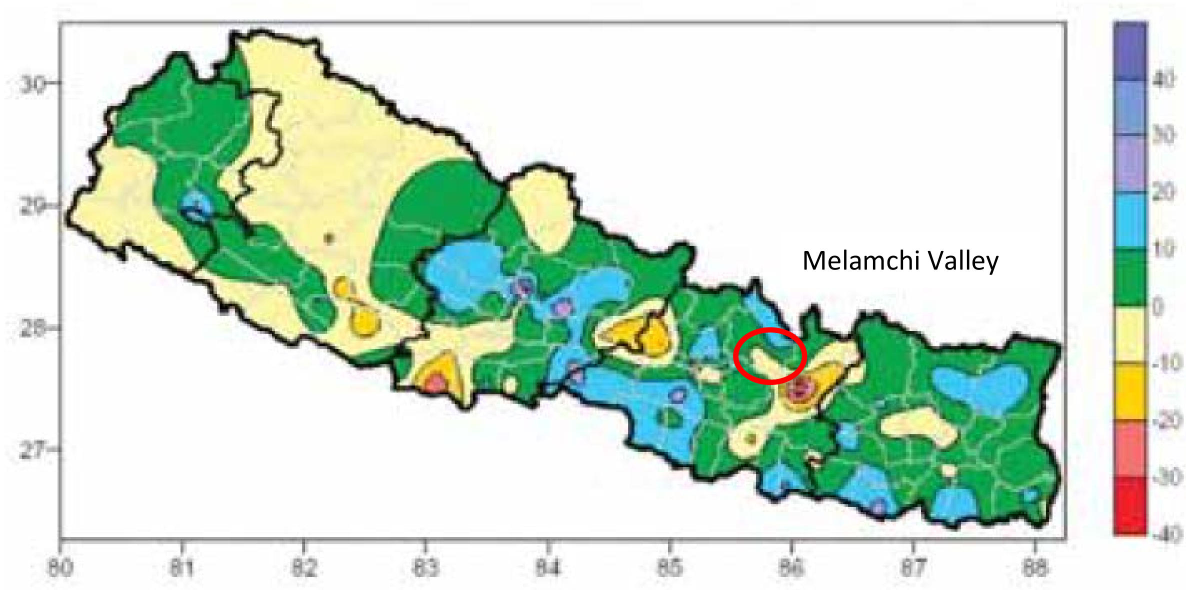
Observed changes in climate indicate that temperatures have increased in Nepal over recent years. The Nepal National Adaptation Programme of Action (NAPA) reviewed two studies that analyzed temperature trends from numerous stations in Nepal.[57] In the first study, Shrestha et al. (1999) found continuous warming across 49 stations for the period 1977-1994, with an average annual rate of 0.06°C. Similarly, a second study conducted by Practical Action (2009) analyzed data from 45 stations from 1996-2005 and found that annual maximum temperatures rose at a rate of approximately 0.04°C. Studies indicated that warming is spatially variable.

Precipitation

The inter-annual variation of rainfall, particularly monsoon precipitation, is large. Observed trends are uncertain and may be part of El Niño and solar cycles. Precipitation data was collected at 166 stations across Nepal from 1976-2005, and the trends are shown in Figure 7. Station observations in the Melamchi Valley reveal an increase of up to 20% in annual precipitation trends.[58] The IPCC (2007) projects a general increase in the intensity of heavy rainfall events and a decrease in the number of rainy days over a large part of South Asia.

[53] Ministry of Environment, 2010.
[54] Khadka and Khanal, 2007.
[55] World Bank, 2013.
[56] Khadka and Khanal, 2007.
[57] Ministry of Environment, 2010.
[58] Ministry of Environment, 2010.

Figure 7: Annual Precipitation Trends during 1976-2005 (mm/yr) (Ministry of Environment, 2010).



Seasonal precipitation patterns have shifted and show a general increase in precipitation in most areas of central Nepal. The increase in precipitation is generally consistent during all seasons: the pre-monsoon, monsoon, post-monsoon, and winter seasons. However, there are a few pockets in central Nepal that have experienced declines during the pre-monsoon and monsoon seasons. According to the map in Figure 7, it appears that the areas with declines during these seasons are near Kathmandu, in the yellow/orange/red areas of the map to the southeast of the circled area.[59]

Glacial Melt and Streamflow

The water resources sector is a key climate vulnerability for Nepal. Warming trends have already affected glacial melt in the Himalayas.[60] There is an extremely high likelihood that glacier retreat and significant increases in the size and volume of glacial lakes are linked to rising temperatures.

Some rivers are already exhibiting a trend towards a reduction in dependable flows in the dry season, and glacier retreat also contributes to streamflow variability in the spring and summer. The increase in size of glacial lakes, making them more prone to Glacial Lake Outburst Flooding (GLOF), presents an additional source of flooding risk.

CLIMATE CHANGE PROJECTIONS

Temperature

Two recent climate change studies in Nepal studies show a higher temperature increase during the winter season than compared to the monsoon season and that warming would occur more rapidly in western Nepal.[61] One of the studies used General Circulation Models (GCM) run with the SRES B2 scenario and showed an annual temperature increase from a 2000 baseline by 1.2°C by 2030; 1.7°C by 2050; and 3°C by 2100.[62] The second

[59] Ministry of Environment, 2010.
[60] Agrawala et al., 2003.
[61] Ministry of Environment, 2010.
[62] Agrawala et al., 2003.

study used GCM and Regional Circulation Models (RCM), projecting an average increase of 1.4°C by 2030; 2.8°C by 2060; and 4.7°C by 2090.[63]

Similarly, the World Bank Climate Change Knowledge Portal projects temperature increases for the Melamchi Valley region. Based on a 1980-1999 baseline, the average annual temperature is projected to increase by 1.29°C by 2020-2039 and by 3.21°C by 2060-2079 (Table 3). However, unlike the national projections, temperature increases in this region are projected to be higher during the pre-monsoon and monsoon seasons.[64]

Table 3: Mean temperature change (°C) in temperature for Nepal (at location 28.1, 84.08) (World Bank, 2013).

Season	Month	1980-1999	2020-2039	Change from 1980-1999	2060-2079	Change from 1980-1999
Winter	January	-6.07	-4.64	1.43	-2.30	3.77
	February	-2.56	-1.07	1.49	1.09	3.65
Pre-monsoon	March	2.22	3.26	1.04	6.04	3.82
	April	8.05	9.18	1.13	12.90	4.85
	May	14.39	16.20	1.81	18.61	4.22
Monsoon	June	16.62	18.44	1.82	19.15	2.53
	July	14.69	15.69	1.00	16.68	1.99
	August	13.90	14.93	1.03	16.45	2.55
	September	11.59	12.51	0.92	14.15	2.56
Post-monsoon	October	5.10	6.76	1.66	8.32	3.22
	November	-0.93	0.12	1.05	1.87	2.80
Winter	December	-4.76	-3.66	1.10	-2.19	2.57
	Average	**6.02**	**7.31**	**1.29**	**9.23**	**3.21**

Precipitation

Climate models project an overall increase in annual precipitation.[65] However, the projections are uncertain given the high inter-annual variation. The models indicate a slight increase in winter precipitation and with great confidence, an increase in precipitation during the summer monsoon months. Based on a GCM run with the SRES B2 scenario, annual precipitation is projected to increase from a 2000 baseline by 5mm by 2030; 7.3mm by 2050; and 12.6mm by 2100. There is moderate confidence across climate models that the monsoon might intensify under climate change.

Streamflow and Glacial Melt

Glacial melt will enhance the variability of streamflows. Continued glacial melt, as a result of higher temperatures, increases the risk of severe inundation from GLOFs and can also reduce dry season flows fed by glacier melt.

[63] NCVST, 2009.
[64] World Bank, 2013.
[65] Agrawala et al., 2003.

Potential Impacts of Climate Change on Project

PROJECT INFRASTRUCTURE AND OPERATIONS

Rainfall and snowmelt are the two main sources of water for the Melamchi River. Thus, the impacts of climate change on the Melamchi water project will be mostly caused by temperature increases and increased intensity and frequency of precipitation events. Additionally, if there are prolonged droughts, the water supply may decline and the quality of the water may be impaired. Since Nepal is not a coastal country, sea level rise will not have an impact on the project.

Temperature Increases and associated climate impacts

Temperature increases may reduce the capacity for the Melamchi project to meet the projected outputs. Increased temperatures may degrade water quality by promoting algal blooms, increasing pathogen concentrations, and lowering dissolved oxygen levels. If the water treatment facilities are not designed to treat the extent of these types of water impairments, treatment costs will increase.

Continued glacial melt under higher temperatures may increase the risk of GLOFs and reduce dry season flows, affecting the variability of the Melamchi River and water supply and quality for the project.

Increased intensity of Precipitation and Storm Events

Changes in precipitation patterns may damage the project infrastructure and affect water quality. The project infrastructure may be temporarily or permanently damaged by inundation, swiftly moving debris, or erosion. Additionally, the storage facilities may not be designed to accommodate sufficient capture during different types of precipitation events, including short, high intensity storms. Loss of power during storm events may disrupt or damage the water treatment facilities and distribution networks.

Frequent and intense precipitation events may accelerate the rate of runoff, erosion and landslides, which can result in increased turbidity loading in the water supply and reservoirs. Water treatment efficiency will be lowered by these changes in water quality. The projected changes in precipitation will also create a need to ensure distribution system integrity to make sure that storms do not contaminate water that has already been treated.

Decreases in water supply and quality will also be experienced during storage and distribution if there are prolonged droughts.

Adaptation Options

Given the persistent water shortages in Kathmandu, the Melamchi water project is one element of increasing adaptive capacity for the city – it provides a new water source that had not been previously available. However, even with this additional source, water supplies may still be inadequate, especially under new climate regimes. Additionally, the project itself may be directly impacted by quantity and quality concerns. In order to minimize the impact of climate change on the project and on the water supply for Kathmandu, deeper examination of the likely impacts on the site and on the project is warranted. As determine by the results of those examinations, a combination of the following adaptation options could be considered to reduce water losses, reduce demand, protect water quality, protect infrastructure, and enhance the capacity of natural systems.

Reduce water losses

- Limit evaporation from storage and distribution infrastructure including reservoirs and exposed ditches by using inexpensive technologies such as floating covers.
- Introduce or improve domestic water supply distribution network monitoring and repair.

- Lining of water conveyance canals to minimize water loss in transit.

Reduce demand

- Educate public, businesses, and agricultural producers on water conservation and efficient practices.
- Improve water use practices in industry and businesses: manufacturing, fixtures, incentives.
- Review appropriate technology and irrigation practices, crop choices to reduce agricultural demand
- Incentivize residential customers to install conservation fixtures.
- Develop tariff structures (increasing block rates or water budgets) that discourage wasteful water practices (large lawns, pools, etc.)

Protect water quality

- Protect source water through improved sanitation and improved watershed protection (e.g., collection of animal waste, better management of agricultural runoff (fertilizers, pesticides), logging and development operations, etc.)
- Protect groundwater by updating and enforcing land use and waste management policies and regulations (e.g., landfills, septic systems, agricultural chemicals, development zoning, industrial chemical use, storage and disposal, siting and underground storage of retail gas stations)
- Improve water treatment technology – ensure that it can withstand increased turbidity and pathogen concentrations.
- Implement advance warning systems if there is a breakdown in the water treatment and distribution system.
- Relocate assets to areas that are less flood-prone.
- Preserve or create/enhance natural buffering systems: e.g., wetlands to accommodate river bank overflows, hold water upstream and promote infiltration rather than rapid runoff, etc.

Protect ecosystem services

- Improve watershed management to increase sustainability of inland freshwater ecosystems.
- Preserve or enhance instream flows to ensure suitable pollutant dilution, dissolved oxygen levels, and cooler temperatures in ecologically vulnerable streams and rivers (e.g., through dam releases, limits on surface water extractions, tree planting/preservation along river banks to provide shading along river banks, etc.).
- Identify important ecosystem services that require appropriate water management, and build/strengthen institutional capacity in environmental management, training, planning, implementation, and evaluation to strengthen these services. Such as: water absorption by wetlands, in-stream flows for navigation and marine ecosystems' sustainability, and annual flooding that provides silt used by farmers, etc.

Monitoring and Evaluation

Monitoring and evaluation will be critical to establish an ongoing understanding of how climate will impact the Melamchi Water Supply Project. Comprehensive monitoring and evaluation activities should take place at regular intervals, during and beyond the construction phase of the project, and seek to monitor three elements of the project: (1) the overall project success, (2) environmental and social impacts, and (3) climate variables.

What to Monitor

ADB's January 2008 report on the Major Change in Scope and Implementation Arrangements includes specifics about the Design and Monitoring Framework to be carried out by the project management consultant. Table 4 is an augmented version of the Design and Monitoring Framework. Fields in red under the "Climate-Related Monitoring" are suggestions of how the project may supplement their monitoring framework to address climate change considerations.

Table 4 - Design and Monitoring Framework[66]

Design Summary	Performance Targets/Indicators	Data Sources/Reporting Mechanisms	Assumptions and Risks	Climate-Related Monitoring
Impact Health and well-being of the people of Kathmandu Valley improved	By the end of the Project (2013): Reduced incidence of water-borne diseases (diarrhea, stomach aches, dysentery, etc.) of population Increased productivity and enhanced disposable income	Ministry of Health statistics Bureau of Statistics Kathmandu residents survey	**Assumptions** Donors and Government of Nepal stay committed **Risk** Political instability during project implementation	Keep detailed records of local temperature, precipitation, and water quality. Periodically consider health and livelihoods of project beneficiaries in light of changing climatic conditions.
Outcome Shortage of potable water in Kathmandu Valley alleviated	By the end of the Project (2013): An additional 170 million liters per day of potable water piped to the inhabitants of Kathmandu Valley from existing 100 million liters per day in 2007	Regulatory body benchmarking Measurement at the outlet of water treatment plant MWSDB M&E system and procedures	**Assumptions** Government of Nepal able to sustain sufficient fund release. **Risk** Project implementation—i.e., Melamchi diversion tunnel civil works under subproject 1—are delayed	Keep detailed records of precipitation and temperature in Melamchi River's watershed. Compare precipitation trends with any changes in the volume and quality of raw water.
Outputs **A. Melamchi Valley Subproject (Subproject 1)** 1. Raw water diverted from Melamchi Valley to Kathmandu Valley by development of infrastructure, i.e. tunnel, road and water treatment	26 km Melamchi diversion tunnel completed and 170 million liters per day of bulk water provided to Kathmandu Valley 25 km access roads and upgrading of 29 km access roads completed Water treatment	Construction completion certificates Water measurement at the outlet of water treatment plant ADB loan review mission reports Financial audit report POE report on social and environmental	**Assumption** Positive public and political support is sustained Government laws and regulations are approved in a timely fashion and are not changed in ways that adversely affect project implementation Sufficient, capable staff available to PMU	Consider how extreme temperature and precipitation events and changes in glacial melt may have improved or hampered construction, social and environmental safeguards, and

[66] ADB, 2008b.

plant 2. Social and environmental support provided in Melamchi Valley 3. Efficient project management established and capacity building attained	plant with potential capacity of 170 million liters per day completed and treating raw water from Melamchi Valley Social development support—including income generation—buffer zone development, health and education program implemented and benefiting inhabitants RAP, PR, and EMP implemented in accordance with its respective plan through the Melamchi Valley Development Committee, and potential negative impact on affected people mitigated PMU established with effective decision-making mechanisms, market-driven performance management system, remuneration system, and standard operating procedures in place	safeguards PMU monthly progress report M&E reports Project Performance Report comprising loan disbursement rates Melamchi residents survey	**Risks** Difficult ground conditions cause cost overruns and construction delays for tunnel civil works Compensation of affected persons is delayed Consensus among local communities is delayed and participatory implementation arrangements fail to materialize	project management activities.
B. Kathmandu Valley Subproject (Subproject 2) 1. Institutional reforms achieved and efficiently operated 2. Water distribution and wastewater system	By the end of the Project (2013): Performance targets under lease and license agreement achieved Water tariff adjusted in accordance with cost recovery	Report of contract compliance unit in KUKL Water tariff publication ADB loan review mission reports Financial audit report POE report on social and environmental	**Assumptions** Positive public and political support is sustained Government laws and regulations are approved in a timely manner and are not changed to adversely affect project implementation Cooperation from non-	Consider how extreme temperature and precipitation events and changes in glacial melt may have improved or hampered construction,

improved by provision of capital works 3. Social and environmental support provided in Kathmandu Valley	principles Water levy paid from Kathmandu Valley inhabitants to Melamchi Valley inhabitants Capital works for BDS and DNI undertaken and potable water supplied 8 hours per day Additional raw water source provides 15 million liters per day Wastewater facilities rehabilitated HEPP, support to a law income customer support unit, and EMP materialized	safeguards PMU monthly progress report Project Performance Report comprising loan disbursement rates Kathmandu residents survey	shareholding municipalities is secured **Risks** Required funds for all phased BDS/DNI are not available Political parties interfere with autonomy of KUKL	social and environmental safeguards, and water management reform activities.

When to Monitor

To adequately monitor and evaluate the project, it should be done on regular intervals over time. The report on the change in scope of the project does not specify timeframes to conduct monitoring and evaluation.[67]

Intervals

The monitoring interval should be contingent on what element of the project is monitored. Annual or even periodic (every five years) monitoring and evaluation may be a sufficiently frequent to determine the overall project success in alleviating water shortages and the social and environmental impacts of the project. However, environmental and climate variables may need to be monitored on a more frequent basis. Environmental impacts may be more prevalent during certain seasons; annual assessments of the environment may not reveal critical impacts, such as snowmelt, that occur during only one part of the year. Similarly, to understand the impact of climate variables on the project, regular monitoring with periodic evaluation would be prudent.

Duration

Since climate projections are always made with a degree of uncertainty and the impacts are likely to be observed over a long period of time (decades, not months), monitoring and evaluation of the impact of climate change on the project should be established and continue for the duration of operation.

To understand the real threat and potential impact of shifts in precipitation, streamflow, temperature, and evaporation on the water supply project, local data should be collected on a regular interval. Local daily measurements would provide an accurate and clear understanding of the climatic conditions on the Melamchi project.

[67] ADB, 2008b.

The water supply project is expected to be in operation for several decades. In addition to monitoring the local climatic conditions, it would be prudent to implement regular monitoring of the project assets – including the diversion tunnel, water treatment plant, and water distribution networks. Regular monitoring of these assets, in conjunction with the climate data would provide a valuable baseline from which to evaluate the operational status for the project.

Resources

ADB. 2000. Summary Environmental Impact Assessment: Melamchi Water Supply Project in the Kingdom of Nepal. http://www.adb.org/sites/default/files/projdocs/2000/seia_melamchi_2000.pdf

ADB. 2008a. Nepal: Melamchi Water Supply Project and Kathmandu Valley Water Services Sector Development Program. Major Change in Scope and Implementation Arrangements. http://www.adb.org/sites/default/files/projdocs/2008/31624-NEP-MCS.pdf

ADB. 2008b. Melamchi Water Supply Project: Melamchi River Water Diversion Sub-project (Sub-project 1) Environmental Management Plan. http://www.adb.org/sites/default/files/projdocs/2008/31624-NEP-SEMR.pdf

ADB. 2008c. Melamchi Water Supply Project: Melamchi River Water Diversion Sub-project (Sub-project 2) Environmental Management Plan. http://www.adb.org/sites/default/files/projdocs/2008/31624-NEP-EMR.pdf

ADB. 2008d. Melamchi River Water Diversion Sub-project: Resettlement Action Plan. http://www.adb.org/sites/default/files/projdocs/2009/31624-NEP-RP.pdf

ADB. 2012a. Melamchi Water Supply Project-Subproject 1. Environmental and Social Monitoring Report. Annual Report: January-December 2012.

ADB. 2012b. Melamchi Water Supply Project-Subproject 2. Environmental and Social Monitoring Report. Annual Report: January-December 2012.

ADB. 2013. Melamchi Water Supply Project, Project Data Sheet (PDS): Details. http://www.adb.org/projects/31624-023/details

Agrawala, Shardul, Vivian Raksakulthai, Maarten van Aalst, Peter Larsen, Joel Smith and John Reynolds. 2003. Development and Climate Change in Nepal: Focus on Water Resources and Hydropower. Organisation for Economic Co-operation and Development. http://www.oecd.org/env/cc/19742202.pdf

Bigfootprint.org, 2013. http://www.bigfootprint.org/t3/fileadmin/Images/Nepal_Districts.jpg

CBS. 2012. National Population and Housing Census 2011 (National Report). Government of Nepal Central Bureau of Statistics. http://cbs.gov.np/wp-content/uploads/2012/11/National%20Report.pdf

Khadka, R. B. and Khanal, A. B. 2007. Environmental Management Plan (EMP) for Melamchi Water Supply Project, Nepal. http://www.bioline.org.br/pdf?er08012

MWSDB. 2012. Melamchi Water Supply Project. http://www.melamchiwater.org/home/melamchi-ws-project.php

Ministry of Environment. 2010. National Adaptation Programme of Action (NAPA) to Climate Change. Government of Nepal. http://unfccc.int/resource/docs/napa/npl01.pdf.

Nepal Climate Vulnerability Study Team (NCVST). 2009. *Vulnerability Through the Eyes of Vulnerable: Climate Change Induced Uncertainties and Nepal's Development Predicaments*. Institute for Social and Environmental Transition-Nepal (ISET-N, Kathmandu) and Institute for Social and Environmental Transition (ISET, Boulder, Colorado) for Nepal Climate Vulnerability Study Team (NCVST) Kathmandu. http://www.i-s-e-t.org/images/pdfs/Climate%20Scenarios%20Report%20(High)_10%20November%2009.pdf

USAID, 2013. Addressing Climate Change Impacts on Infrastructure: Potable Water Systems Fact Sheet. U.S. Agency for International Development. Internal Resource.

World Bank, 2013. Climate Change Knowledge Portal: Nepal. http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Asia&ThisCCode=NPL

World Health Organization (WHO). 1998. Aluminum in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality.
http://www.who.int/water_sanitation_health/dwq/chemicals/en/aluminium.pdf.

PT Weda Bay Nickel Project, Indonesia

PT Weda Bay Nickel Project Site, Halmahera Island, Indonesia (Credit: Muhammad Ector Prasetyo, 2006).

Table of Contents

List of Figures

List of Tables

Project Background

INTRODUCTION

The PT Weda Bay Nickel (WBN) project is a nickel and cobalt mining and hydrometallurgical processing development on the island of Halmahera located in the North Maluku Province of the Republic of Indonesia (Figure 1). The nickel deposit in Central Halmahera and East Halmahera Regencies is one of the largest undeveloped resources in Indonesia, with 5.1 million tons of nickel. At full capacity, the plant is expected to treat approximately 4.5 million metric tons of dry ore each year, producing over 65,000 tons of nickel and 4,000 tons of cobalt.[1]

Figure 1. Project Location

Strand Minerals (Indonesia) Pte. Ltd of Singapore, the project developer, is jointly owned by Eramet SA of France and Mitsubishi Corporation of Japan. Strand Minerals owns 90 percent of PT[2] Weda Bay Nickel and the remaining 10 percent is held by PT Antam (Aneka Tambang). The Indonesia government owns 65 percent of PT Antam.[3]

The total area to be used for the first 30 years of mining and processing operations is estimated to be approximately 2,650 ha.[4] In addition to the construction of the mine, additional facilities will include upgrading access roads, an aircraft landing strip, a residue storage facility, a limestone processing plant, the main nickel-cobalt ore processing plant, a dedicated port and barge loading facility, and accommodations (including housing and other facilities for the workforce).[5]

TIMELINE

The WBN Project will be developed in two phases and the construction of the facilities will also be phased. [6]

- Finance Phase I: Exploration and Feasibility
- Finance Phase II: Construction and Operation
    - Operation Phase I: Develop plant with capacity to produce 35,000 tons of nickel per year
    - Operation Phase II: Expansion of additional 30,000 tons capacity

The project start-up activities began in 1996 and the first nickel production is presently scheduled for 2017. A brief project timeline follows.

1996: The Weda Bay Nickel Project commenced.

1997: The Tanjung (Tg) Ulie Camp was established. It now includes workers' accommodations.[7]

1998: The President of Indonesia signed the Contract of Work (CoW) for the WBN project. The initial entitlement for the CoW was for 120,500 ha.

[1] WBN, 2013.
[2] PT refers to Perseroan Terbatas, meaning Limited. PT Weda Bay Nickel is often referred to as WBN.
[3] IFC, 2011.
[4] MIGA, 2010.
[5] MIGA, 2010.
[6] WBN, 2013.
[7] MIGA, 2010.

1999: Forestry Law No 41 was passed and introduced new regulations that impacted the WBN project. Three-year exploration phase begins.

2001: Conducted initial basic environmental baseline studies with support of an external environmental consultant (Dames & Moore).

2006: Eramet SA acquired participation in the WBN project.

2007: Approval of one-year Test Pit Exploration Activity and exploration in the forest area of North Maluku.[8]

2008: Creation of the PT Weda Bay Nickel company. Environmental Resources Management prepared the requisite social and environmental impact studies (AMDAL[9]). The AMDAL consists of several documents, including the Environmental Impact Statement (ANDAL), the Environmental Management Plan, and the Environmental Monitoring Plan. The sponsor conducted an audit of the project and identified the need for additional studies, including an Environmental Social and Health Impact Assessment as part of a Bankable Feasibility Study. Project sponsors commenced a Local Development Support program to provide assistance to 12 local communities.

2008-2010: Development activities accelerate toward commencement of construction in 2011.[10]

2009: AMDAL received approval from the Head of the Provincial Environmental Impact Management Agency of North Maluku Province. Participating agencies commence socialization and negotiations for land acquisitions for processing plant and accommodation areas.

2010: Indonesian NGOs and concerned citizens filed a complaint against the project with the International Finance Corporation (IFC)'s Office of the Compliance Advisor Ombudsman (CAO).[11] MIGA and the World Bank visited the project site and nearby villages.[12] MIGA issued a guarantee of $207 million to Strand Minerals (Indonesia) Pte. Ltd of Singapore.[13] The sponsor updated the AMDAL and carried out a gap analysis.

2011: WBN started Land Preparation Construction, with the intention to prepare sites related to the project infrastructure planned for the construction and operation phases.

2012: WBN's Environmental Policy approved by company management.[14]

2013: Expected go-ahead decision from shareholders to begin construction.[15] The government of Indonesia will complete its review of all mining contracts by December 2013.[16]

2017: Expected date for first nickel production.

2064: End of initial operations (subject to change).[17]

[8] ERM, 2010.
[9] Compliance with the AMDAL process (regulatory environmental impact assessment) for new mining projects is compulsory by law in Indonesia.
[10] ERM, 2010.
[11] IFC, 2011.
[12] MIGA, 2010.
[13] MIGA, 2013a.
[14] MIGA, 2013b.
[15] There is no indication from the website or project documents that construction began in 2013.
[16] Wulandari, 2013.
[17] ERM, 2009a.

FUNDING

The total project cost is not available.

Funding Phase I: Anticipated cost for the initial phase was US $230 million. MIGA issued a guarantee of US $207 million for the project exploration and feasibility study.

Funding Phase II: Information about the funding sources and amounts for the second phase of the project is not available. Funding is likely coming from private funders that are not required to publicly disclose the financial investment.

PROJECT LOCATION

The PT Weda Bay Nickel project will be located on Halmahera Island in North Maluku Province, to the east of Sulawesi in the Indonesian archipelago. The project area is located at the northern end of Weda Bay, in Central Halmahera and East Halmahera Regencies, as shown in Figure 2.

Halmahera Island is largely undeveloped and local communities rely heavily on natural resources. The Land Preparation for Construction (LPC) study area includes approximately 16km^2 in the coastal area near the proposed plant. The receiving and processing base will be located near the villages of Lelilef (Sawai and Woebulen). Veins of ore located in the Nuspera and Kar Kar ridges are in close proximity to the Lelilef villages. Gamef village and the Forest Tobelo people also occupy land near the Contract of Work. While land acquisition is minimal, the project is expected to impact lands on which the local populations rely for sustenance. The Forest Tobelo people are known to inhabit the inland forests; they are nomadic and subsist on hunting and gathering.[18]

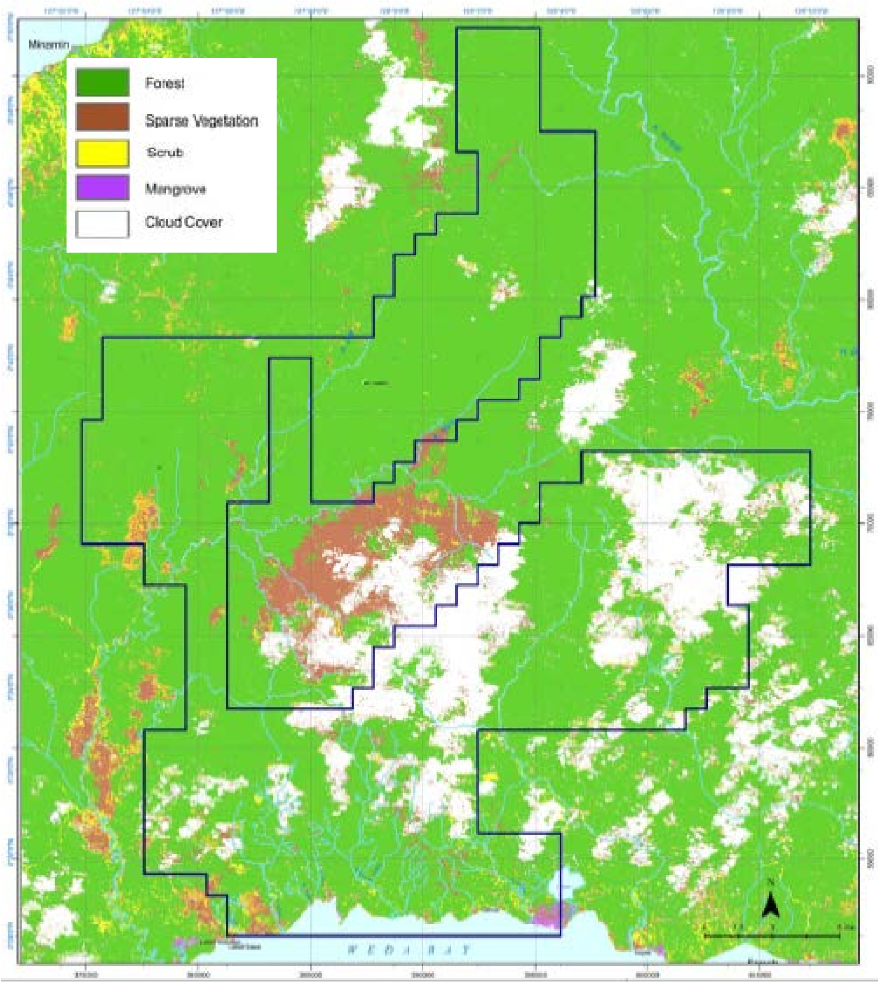
Figure 2: Specific project location on Halmahera Island (AECOM, 2011).

Halmahera Island is generally hilly or mountainous with floodplains in some areas, including the mouth of Ake Kobe that is adjacent to Weda Bay on the eastern coast of the southwest arm. The highest point on the island is Bukit Saolat at 1508m, located in the central part of the island.[19] A large portion of the WBN CoW, 45.64%, is classified as "moderately steep" with slopes ranging from 15-25%.[20]

[18] MIGA, 2010.
[19] AECOM, 2011.
[20] AECOM, 2011.

The WBN CoW spans 54,874 ha that contain mangrove and fresh water swamp forest, various lowland forest habitat types, and lower montane forests. As shown in Figure 3, the majority of the land cover in the CoW is characterized by forest. Nearly half of the total area is designated 'Protection Forest'[21] by the Ministry of Forest.[22] There are no 'Conservation Forest'[23] areas within the CoW, but the Aketajawe National Park lies 3.2 km to the west of the CoW and the Lolobata National Park is located 31.5 km to the northeast. There is no expected drainage from the CoW into these National Parks.[24] Although the Forestry Law No 41 (1999) stipulates that 'open cast mining' would not be allowed in 'Protection Forests,' a 2004 Presidential Decree provided an exemption to 13 companies that had prior approval, including WBN.[25]

Figure 3: Land cover within Contract of Work (CoW) (ERM, 2010).



Two major rivers are located within the borders of the WBN project; the Kobe River on the west side and the Sagea River on the east. Large portions of the CoW are located within their watersheds, see Figure 4. Several smaller watersheds are also located within the project area; Doma, Wosea, Tjetju, Gowomdi, Sake, Sesliwisini, and Gemaf Rivers all flow into Weda Bay, as does the spring fed Sagea Lagoon.[26]

For the first thirty years of operations, mining will be mainly from the Tofu Bleuwen, Bukit Lumber (Santa Monica), and Ake Jira/Bonko Kfan deposits, and from the coastal deposits of Nuspera, Ake Sake, Uni-Uni, Biri-biri, and Kakara. Subsequently, deposits of Boki Mekot, Ake Lipe, Ngowen, and Jiguru will be mined.[27] See Figure 5 for details about the location of ore deposits within the CoW.

[21] The Forestry Law No 41, 1999 defines 'Protection Forest' as "as forest area having the main function of protecting life-supporting systems for hydrology, preventing floods, controlling erosion, preventing seawater intrusion and maintaining soil fertility."
[22] MIGA, 2010.
[23] The Forestry Law No 41, 1999 defines 'Conservation Forest' as "as forest area with specific characteristics, having the main function of preserving plant and animal diversity and its ecosystem."
[24] IFC, 2011.
[25] IFC, 2011.
[26] ERM, 2010.
[27] ERM, 2010.

Figure 4: Watersheds within Contract of Work (CoW) (ERM, 2010).

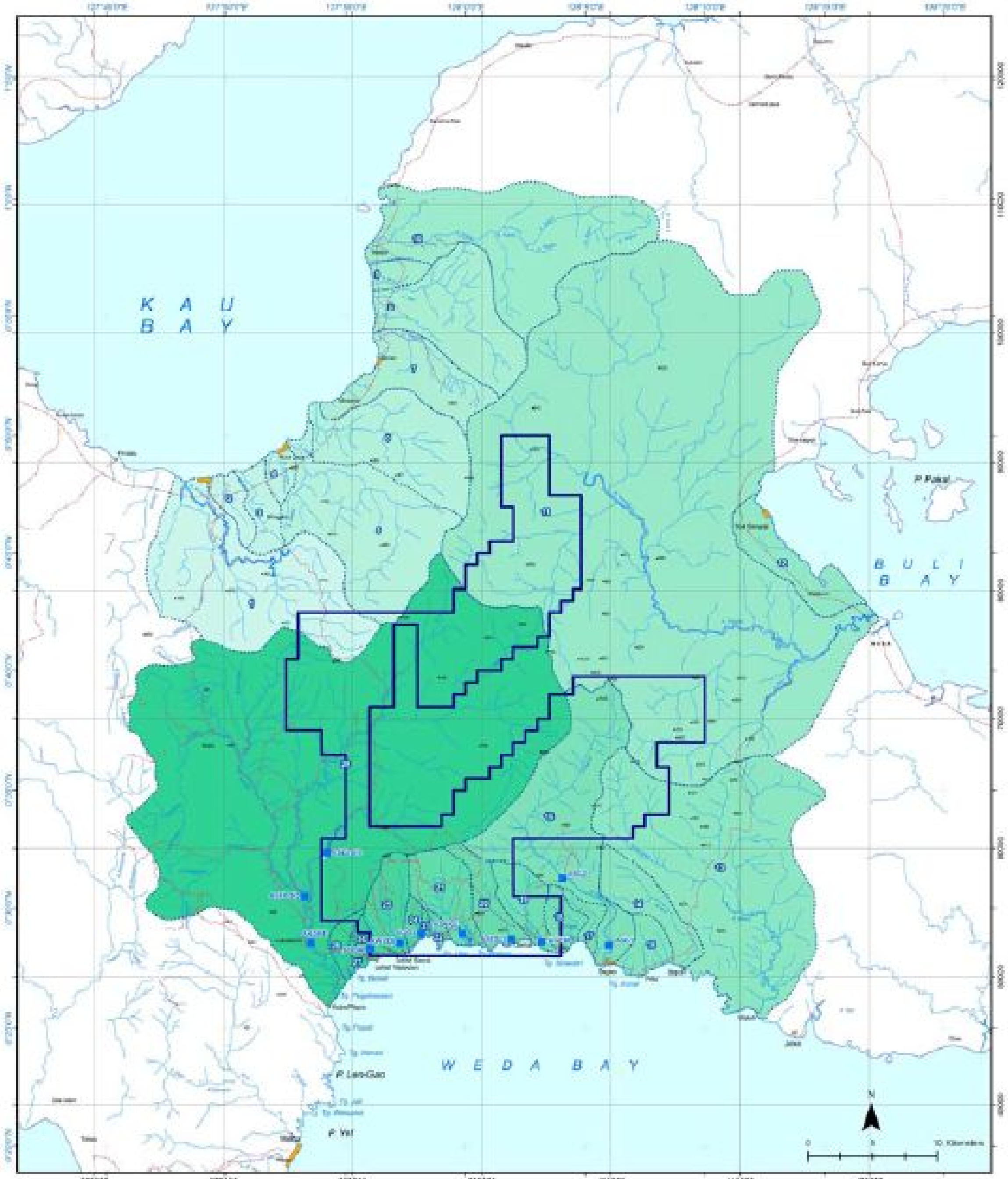
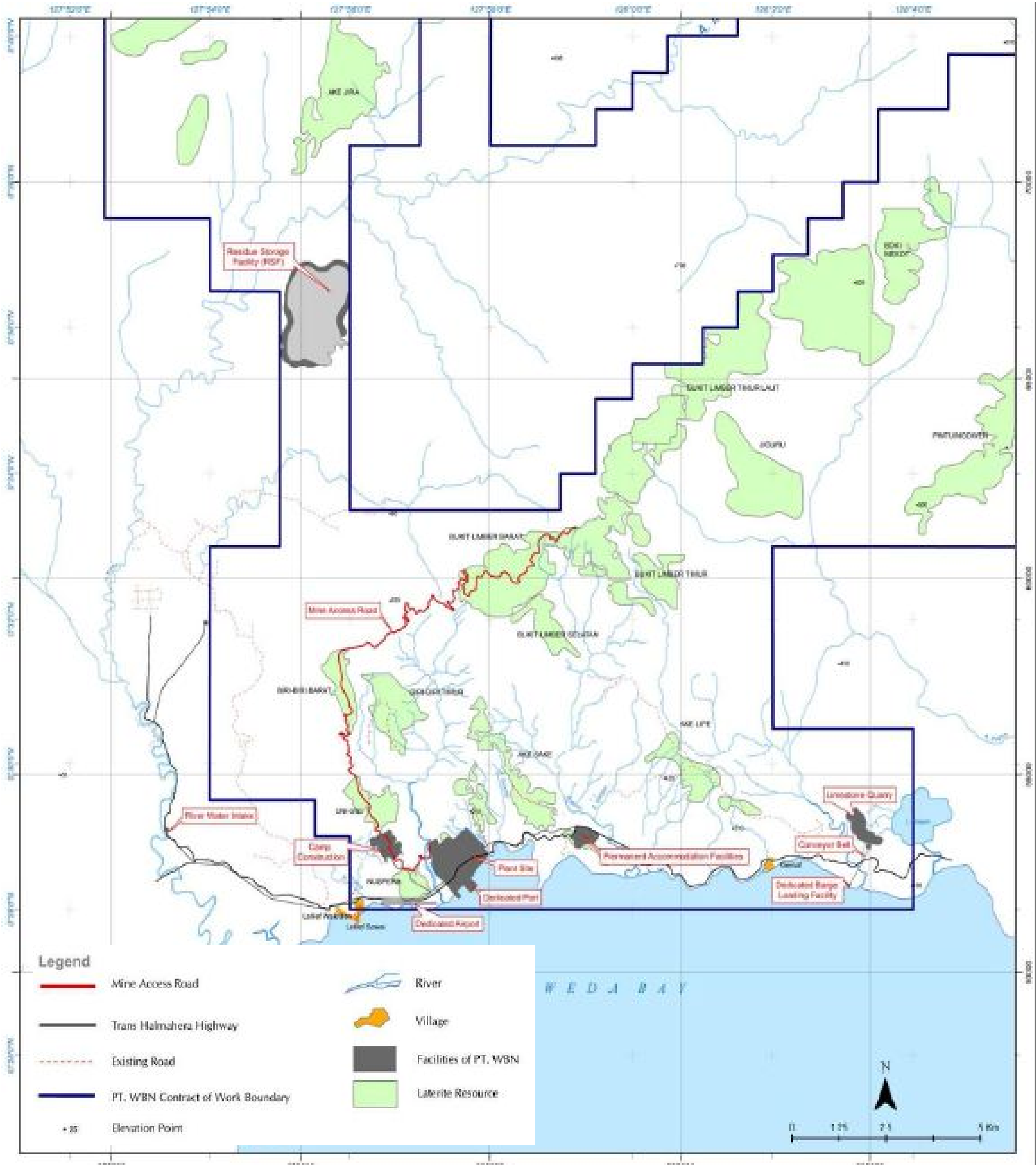


Figure 5: Project Layout, Includes Ore Deposits and Infrastructure (ERM, 2009a).

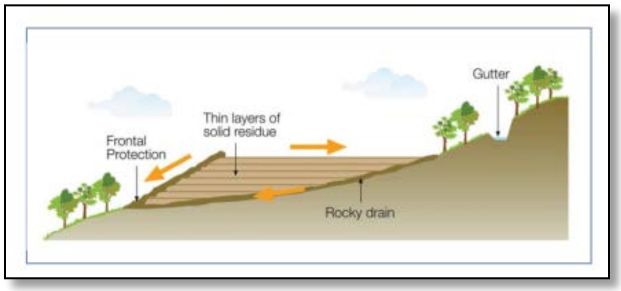


PROJECT ASSETS AND OPERATIONS[28]

The total project area for the first thirty years of operation will be approximately 2,650 ha, which includes the following (see Figure 5 for specific site locations):

- 1,800 ha of mining areas;
- 220 ha residue storage facility is located in the upper watershed of the Jira River, inside the CoW. The hydrometallurgical process generates two streams of solid residues that will be stored separately to avoid possible oxidation. The process will produce approximately 6.8 million dry metric tons of iron residue and 0.254 million dry metric tons of manganese-bearing residue. The area was selected for the storage facility because the developers believe that site conditions should provide a low permeability liner that will prevent contaminated water from the filter cake from entering the groundwater system. It is also removed from human activity, and there is a small external catchment area that can be used to redirect surface water flow from the dump. The residue storage facility will be operated in successive cells that will stay active for approximately five years before being capped and vegetated to minimize runoff before discharge in the Jira River.[29] See Figure 6 for the site design;
- 120 ha processing plant area will include site access roads, extension of an existing airstrip, temporary power generation, and a barge landing facility;
- 100 ha limestone quarry and crushing plant;
- 80 ha mining and access roads – the main access road is planned on the western part of the CoW from the process plant site to Bukit Limber Deposit; additional roads will be built as needed. Main roads will avoid crossing public roads;
- 48 ha temporary housing accommodation facility – located to the west of the proposed plant site location and will house the 8,000-10,000 person workforce required for the construction phase. The facility includes health, safety, security, recreational, and operational facilities;
- 40 ha dedicated port and barge-loading facility – comprised of three main facilities: container terminal (located on steep part of fringe reef and will not require dredging), liquid bulk terminal (designed to receive 225m long and 14.5m wide tankers), and a barge-landing facility (dedicated port facility to import construction materials);
- 36 ha airstrip;
- 29 ha permanent accommodations facility, including housing, a mess hall, medical staff, etc. – operating labor force is estimated to be 3,000. WBN anticipates that approximately 50% will be recruited locally; and
- 250 ha of other infrastructure, including topsoil and overburden stockpile areas, borrow pits, drainage and sediment ponds, etc.

Figure 6: Design of Residue Storage Facility (ERM, 2009a).



Although additional areas will be required for haulage and access roads, most other facilities (such as accommodations, the air strip, etc.) will not be expanded for a mining period that extends beyond the initial thirty years. Additional mining areas include Lipe, Jiguru, Boki Mekot, and Ngowen – the expanded project area for this additional development is anticipated to be up to 2,000 ha, approximately doubling the extent of the mining areas.

[28] ERM, 2009a.
[29] ERM, 2009a.

Environmental and Social Impacts

The WBN project is classified as Category A under MIGA's Environmental and Social Review procedures.[30] A project is classified as Category A if "it may have potentially significant adverse social or environmental impacts that are diverse, irreversible, or unprecedented".[31] In compliance with Indonesian environmental regulations, WBN completed an Environmental Impact Assessment called AMDAL, which was approved by Indonesian authorities in June 2009. In 2010, WBN completed and submitted to MIGA the Environmental and Social Impact Assessment for the exploration and feasibility phase of the project. In addition, WBN is conducting a more comprehensive Environmental, Social and Health Impact Assessment with additional baseline studies and impact management plans to meet IFC Performance Standards.[32] The Environmental, Social and Health Impact Assessment covers the construction and operation of a plant with capacity to produce 35,000 metric tons of nickel per year. A similar process will be prepared for the subsequent expansion of an additional 30,000-ton capacity.[33]

Environmental Impacts[34]

Under the exploration and feasibility phase of the project, activities include test drilling and exploration in ecologically sensitive areas, but the impacts on critical habitats, species biodiversity, and from pollution are not expected to be significant. Monitoring performed by the project has not shown any significant impacts from exploration and feasibility activities.[35] The major significant potential impacts will occur during the construction and operation phases. These potential impacts include soil erosion, pollution from waste disposal, and negative effects on biodiversity from project construction and operations and population influx, which can be irreversible if not addressed properly.

During the construction phase, land clearing will increase soil erosion and runoff from disturbed areas and steeper terrain in and around the mining sites. Erosion can increase suspended sediment levels in surface waters, with potential negative impacts on aquatic flora and fauna. Land clearing will affect several watersheds in the area, including Kobe, Wosea, Sake, Tjetju, and Gemaf Rivers. As the rivers discharge into Weda Bay, sediment deposition can be detrimental to coral reefs. However, incidences of high suspended sediment levels are expected to be short and marine ecosystems will be able to recover between events. WBN considers the impacts of erosion on aquatic life reversible once erosion control measures are established, which are detailed under the Environmental and Social Commitments section of this report.

Spills or accidental discharge of fuel or lubricants can increase the risks of localized marine pollution. There will also be dust and noise from construction activities. However, the noise levels in nearby villages are expected to be within national limits and World Bank Group Environmental, Health and Safety Guidelines for residential areas.

Port construction will result in negative but localized impact on marine organisms. Coral reefs in the port construction site will be damaged. However, PT Weda Bay Nickel reports that the affected reefs only account for 1% of the total areas of reefs in the project area. Port construction will also increase total suspended solids and oil and grease, with potential negative but localized effects on marine organisms. Nevertheless, the impacts will be greater if currents carry suspended solids beyond the immediate port area.

Population influx during the construction phase can create significant negative impacts on biodiversity in the region. WBN plans to minimize the environmental impacts caused by the influx of construction workers formally

[30] MIGA, 2010.
[31] MIGA, 2013c.
[32] WBN, 2013.
[33] WBN, 2013.
[34] MIGA 2010.
[35] MIGA, 2010.

hired by the company by housing them in a self-contained temporary construction camp and using a "fly-in, fly-out" approach, with no families accompanying the workers. However, it will be much more difficult to control the in-migration of other job-seekers into the area.

During the operation phase, expected negative environmental impacts include soil erosion, pollution of surface water, ground water, and marine water due to waste disposal, air pollution due to dust and air emissions, vibration and noise pollution, and negative impacts on biodiversity.

If not properly mitigated, the increased erosion and runoff from land clearing, topsoil and overburden removal and stockpiling will impact water quality and the abundance of freshwater plankton and benthos.[36] In addition, port activities and the disposal of liquid effluent will affect seawater quality, with potential negative impacts on the abundance of plankton, benthos, and coral life forms in the area around the port and close to the discharge area.

WBN indicates that the mined areas will be rehabilitated progressively. At any point in time, the total disturbance from mining is anticipated to be always less than 500 ha. The company plans to extract from nine ore deposits during the first 30 years of operations. Some of the ores are located in more elevated ridge tops within a Protection Forest area that have historically been disconnected from human activities. Land clearing is expected to cause habitat destruction and fragmentation. However, PT Weda states that the habitats involved are spread out in the region and a significant regional loss of flora and fauna is unlikely as a result. However, the issue requires additional analysis once the mining pit locations are finalized.

WBN will carry out substantial forest rehabilitation activities to comply with Indonesian laws and MIGA performance standards. In 2007, PT Weda established an 11 ha area to test rehabilitation and reforestation methods to be applied to the full-scale operations. While Eramet SA has been successful in a rehabilitating and reforesting project of mining areas in New Caledonia[37], full restoration of rainforest ecosystems is difficult due to the fact that species have been forced out of larger areas and may not be able to reestablish residency in the disturbed area. As a result, significant concerns remain about the impacts of the project on biodiversity.

In addition to the direct impacts, the project will have indirect environmental effects through the in-migration of job seekers and service providers. The population influx can result in clearing of forest for settlement and cultivation and small-scale logging, fires associated with land clearing, and illegal hunting. The mining roads will provide access to previously inaccessible areas, further exacerbating these impacts.

Several Indonesian NGOs and concerned citizens requested assistance from the CAO in addressing a number of environmental and social concerns related to the WBN project. Environmental complaints regarding the following stipulations, reported to the CAO included:[38]

Social and Environmental Assessment and Management Systems

- WBN's Environmental Impact Analysis did not clearly consider various alternatives for most of the impact and did not prepare clear documentation about the risks of choosing alternatives, including for the exploration and feasibility stages.
- Even though the ANDAL[39] covered all phases of the project, the Environmental and Social Impact Assessment (ESIA) of Exploration and Development did not honestly cover construction, operations and decommissioning or closure.
- The basic data for biodiversity, sedimentation, and well water includes inadequate information to assess its accuracy.

[36] Benthos are organisms that live on the ocean floor – known as the "benthic zone."
[37] An archipelago in the southwest Pacific Ocean
[38] IFC, 2011.
[39] ANDAL is the first section of the AMDAL.

- Forest destruction and water crisis will result from opening the nickel and cobalt mine in Santamonica. Destruction of part of the Ake Kobe protection forest is unavoidable and it will not be possible to completely restore it to the original condition.

Pollution Prevention and Abatement

- Sedimentation risks were not clearly identified, especially for operations close to ecologically sensitive (Protection Forests, coral reefs) and National Parks.
- Pollution risks were not adequately identified in project documents (for all stages).
- Sampling methods/samples, including sample measurements, are not available in the project documents; accuracy of the data cannot be confirmed.
- Health threats caused by asbestos levels and air pollution from sulfuric acid production have not been adequately evaluated.
- Methods for estimating projected contamination water flow are not available; claims that there will be no cumulative effect of contamination into the sea cannot be justified.
- Existing data are inadequate to verify the statement that replenishing the ground water will take place in limestone mines.
- Project plans did not sufficiently explain the pollution risks.
- The type of sewage treatment is undefined.
- Efforts to mitigate the impact of sedimentation and erosion may not be sufficient.
- The ESIA does not consider the construction of zero disposal facilities, as indicated in IFC/MIGA Performance Standards Guidelines.
- Data for the residue storage facilities is not sufficient to confirm potential effectiveness.
- Pollution of water sources and the sea from disposal of tailings into the sea and the Santamonica mine shaft will introduce pollution into the local rivers.

Biodiversity Conservation and Sustainable Natural Resource Management

- Information on biodiversity is insufficient, inadequate, and not accurate enough.
- Critical habitat is not properly identified.
- Protected areas are not properly considered and a despite the National Park that is within 4km from the project, the ESIA did not discuss a buffer zone.
- Assessment of the deforestation impact focuses on the mines and fails to include the cumulative impact on deforestation at the construction and operation stages, and forest cutting activities by other parties.
- The wood from land clearing will be sold and would conflict with the exemption if there are commercial felling operations in tropical rain forests.

Social Impacts

The project will require acquisition of 425 ha of mostly agricultural land for the exploration and feasibility phase; families will not be physically displaced from the land, but may face economic displacement in some cases.[40] The majority of land uses in the project area are held through traditional claims, in which most users do not hold formal land title certificates. The villages of Lelilef Sawai, Lelilef Woebulen, and Gemaf are the villages primarily affected by the planned land acquisition.

The majority of social impacts of the project are expected to arise with the construction and operation phases of the project.[41] The potential project impacts on community health, safety, and security are associated with the project infrastructure and equipment and hazardous materials. The clearing of land and planting on and near future drilling sites can cause health and safety issues. WBN plans to work with the local government and communities to prevent uncontrolled and incompatible developments that could increase the community

[40] MIGA, 2010.
[41] MIGA, 2010.

health, safety, and security risks. If not properly mitigated, the project's environmental impacts on biodiversity and air, water, and soil quality as detailed above can negatively affect the health and livelihoods of local communities. Additionally, the influx of workers would lead to increased exposure to diseases, community unrest, increased crime, and strain on scarce physical infrastructure and health services. During peak construction, the project is expected to employ 10,000 workers.

The Forest Tobelo, the Sawai people, and the Village Tobelo are indigenous groups within the project area. The project will impact the Forest Tobelo the most, as they are a nomadic people who inhabit the inland forests of Halmahera and depend on hunting and gathering for subsistence. The project may hinder their movements in the forests and affect their livelihoods. The Forest Tobelo generally avoid contact with other inhabitants of Halmahera. As a result, it will be difficult to engage them in the project design and implementation process.[42] The extent to which the Forest Tobelo depend on resources within the project area is unknown. The WBN project team will conduct a study on the potential project impacts and mitigation measures on the Forest Tobelo. The project's community development plans will include a chapter for the Forest Tobelo as a vulnerable group. However, it is unclear when the community development plans will be completed.

In 2011, the complainants to CAO raised various social issues.[43] The Environmental and Social Impact Assessment hoped that there would be no physical dispossession of families from their homes. However, the complainants found that Tobelo Forest people live in the project region would be required to be relocated, and WBN did not document the impact that might occur and get information and involve the traditional community. In addition, WBN did not fully map and design the project to protect or avoid significant damage to cultural heritage. The complainants also claimed that WBN falsely reported at an attendee of consultations with the local civilian society and some local NGOs, and that there was a lack of accessibility to open information documents.

The complainants also believe that other social risks may arise that WBN has not considered. The mining operations have the potential to trigger conflicts with the local community related to forest resources if access into the forest will be restricted. The Batu Gua Lubang community fears that a sacred site in the Ake Kobe forest region will be damages from explosions from the project. Lastly, the pollution of the water from the mining operation wastes will eliminate the community's access to clean water and sources of healthy food, and will damage their source of income.

ENVIRONMENTAL AND SOCIAL COMMITMENTS

PT Weda Bay Nickel (WBN) states that the project is being developed in adherence with the Equator Principles[44] and IFC Performance Standards[45], as well as with relevant Indonesia and international regulations. Since 2008, WBN has been conducting environmental (e.g., water, air, soil, biodiversity, habitats, fauna and flora), social, and public health baseline studies. The project states on its website that it is committed to (1) evaluating project's impacts in order to effectively manage them, (2) preventing and minimizing pollution risks, (3) protecting and conserving terrestrial and marine biodiversity through sustainable management of natural resources, (4) protecting communities and respecting indigenous cultures, (5) promoting and implementing safe working conditions and practices, and (6) avoiding forced migration and mitigating effects linked with land use of affected people.[46]

---

[42] MIGA, 2010.
[43] IFC, 2011.
[44] A credit risk management framework for determining, assessing and managing environmental and social risk in project finance transactions. See http://www.equator-principles.com.
[45] A summary of the IFC Performance Standards is available at: http://www.wedabaynickel.com/en/commitment-to-people-and-nature/impact-assessments/#equ.
[46] WBN, 2013.

WBN's Indonesian Environmental Impact Assessment (AMDAL), completed in 2009, includes an Environmental Management Plan with measures to mitigate the environmental impacts of the project. WBN's Exploration and Development Environmental and Social Impact Assessment, which was submitted to MIGA in 2010, includes an Environmental and Social Management Plan specifically for the exploration and feasibility phase. The more comprehensive Environmental, Social and Health Impact Assessment currently under development will include mitigation measures to the significant environmental, social, and health impacts identified.[47] As the key significant impacts are expected to occur during project construction and operation, this section discusses some of the main environmental and social mitigation measures during these phases. For a full list of social and mitigation measures, see the Indonesian AMDAL Environmental Management Plan[48] and the Exploration and Development Environmental and Social Impact Assessment[49].

In January 2012, company management approved WBN's Environmental Policy, which is available in Bahasa Indonesia, English, and French. The policy is integrated into the Eramet Sustainable Development Policy, IFC/MIGA Performance Standards, and international industry practice. The policy's 12 key principles are summarized in the Environmental and Social Review Summary as follows:[50]

1. Base Environmental Management Program and Environmental Management System on IFC/MIGA Performance Standards (Performance Standard 1: Social and Environmental Assessment and Management Systems)
2. Articulate employees, managers and subcontractors roles and responsibilities
3. Work constructively with stakeholders
4. Comply with all relevant Government of Indonesia laws and regulations
5. Ensure consistency with IFC/MIGA Performance Standards
6. Share environmental and scientific knowledge
7. Assess, actively manage, and monitor environmental impacts and risks
8. Practice efficient use of raw materials, energy and water, and minimize waste and harmful emissions
9. Ensure safe and responsible use, through recycling and end of life of our products
10. Fulfill agreements upon closure / decommissioning
11. Maintain local communities and indigenous people's access to ecosystem services
12. Protect and conserve biodiversity

Environmental mitigation measures

Soil erosion management. WBN will implement erosion control measures to reduce erosion from topsoil and overburden removal and stockpiling. The soil and rock removed from the mining area will be stored in stockpiles surrounded by berms and stabilized by a rock protection and a vegetation cover. Drainage in and around the stockpile will be constructed to drain rainfall runoff and ensure the stability of the stockpile. Erosion control measures will also be applied as needed to reduce erosion of other susceptible areas such as the waste limestone dump, limestone stockpile, and other disturbed areas outside the mine pits.[51]

Surface water management. To prevent sedimentation and control suspended solids in the discharge water, WBN will construct drainage and sedimentation pond networks before forest clearing for pit development. Water runoff will be drained and collected in sedimentation ponds prior to discharging into the natural stream systems.[52]

---

[47] WBN, 2013.
[48] ERM, 2009b.
[49] ERM, 2010.
[50] MIGA, 2013b.
[51] MIGA, 2010; WBN, 2013.
[52] MIGA, 2010; WBN, 2013.

Rehabilitation and reforestation. WBN will progressively rehabilitate the mining areas. The removed overburden and top soil will be returned to the mined-out areas and trees will be replanted on them.[53]

Hydro-metallurgical process waste management. WBN indicates that it will adhere to not only Indonesian regulations but also international good practices and IFC guidelines and performance standards for air emissions, wastewater, solid waste, surface and groundwater quality and sea water quality. Water from the processing plant will be treated and monitored for compliance with Indonesian regulations and international standards before it is released to the sea. Solid waste will not be discharged into the marine environment. They will be neutralized and dewatered at the plant site and transported to the Residue Storage Facility.[54]

Social mitigation measures

The land acquisition process is designed to acquire the land only where it is unavoidable, at a fair price, and with minimal impact on the value of other nearby land.[55] Negotiations will be conducted based off an independent land market price survey and land value appraisal that was completed in January 2010. In cases where the land acquisition would result in loss of livelihoods, the land-owners are entitled to assistance including compensation for lost assets and transitional support to help them establish sustainable livelihood resources.

The influx of workers will be housed in a temporary construction camp. WBN will develop a strategy to reduce the attractiveness of in-migration and manage the impacts of the in-migration that would still occur.

To protect the safety of the communities, industrial activities and sites will be separated from communities and access will not be allowed. For example, a dedicated airport used during the exploration and feasibility phase is fenced and closed to community access and traffic management plan will be developed to mitigate traffic accident risks during the construction and operation phase.[56]

WBN is continuing to develop numerous assessments and plans to understand and mitigate social impacts. The Environmental, Social and Health Impact Assessment under development will include:[57]

- Community Social Assessment
- Public Consultation and Disclosure Plan (PCDP), Preparation and Implementation
- Community and Indigenous Peoples Development Plan Preparation
- Cultural Heritage Assessment
- Land Acquisition and Resettlement Action Plan (LARAP)
- Human Health Risk Assessment
- Public Health Impact Assessment
- Labor and Working conditions
- In-Migration Management Plan

ADHERENCE TO ENVIRONMENTAL AND SOCIAL COMMITMENTS

In 2011, several Indonesian NGOs and concerned citizens requested assistance from the CAO in addressing a number of environmental and social concerns related to the WBN project.[58] See the Environmental and Social Impacts sections of this report for details on the complaints submitted to the CAO.

---

[53] WBN, 2013.
[54] WBN, 2013.
[55] MIGA, 2010.
[56] MIGA, 2010.
[57] WBN, 2013.
[58] IFC, 2011.

Environmental commitments

PT Weda Bay Nickel has engaged in activities to protect the terrestrial and marine biodiversity of Halmahera Island. Since 2008, WBN has conducted a rehabilitation and reforestation trial program. An area of 12 ha was cleared in the Bukit Limber resource area for a test pit (see Figure 7), which was used to test various types of reforestation methods. WBN reports that the reforestation program has shown a 90% survival rate for over 7,000 tree seedlings so far. Additionally, WBN established two tree nurseries (one in the coastal area, the other in the lower mountains' forest area) to test the ability of a variety of local floral species to adapt to disturbed soils (Figure 8). The nurseries have been able to propagate over 30 local tree species with a high survival rate. However, WBN notes that additional research will be needed to increase the number of tree species that survive.[59] WBN has also established six permanent forest habitat monitoring plots to monitor the impact of mining operations on the surrounding environment. It developed a field booklet of flora in the CoW to raise awareness among local communities and project employees on the diversity of flora in the area.[60] Additionally, WBN indicates that it is working with the local government and other partners to protect coral reefs in the project area.

Figure 7. Bukit Limber test pit (WBN, 2013).

Figure 8. One of the two tree nurseries (WBN, 2013).

Social commitments

The project sponsors started a Local Development Support program in 2008 to address potential impacts on the community.[61] The local development efforts were focused in the four following areas: education; health care; agribusiness; and improving village infrastructure. The program was expanded to cover 12 villages in Central and East Halmahera regencies and the 2009 budget for the local development program was over US $1 million. Activities under the program included financing permanent doctors and nurses in the two villages of Halteng and Haltim, and launching programs for dispensary renovation and clean water.

WBN has also contributed to additional community-building efforts.[62] For example, WBN contributed to projects to develop public sanitation in 8 villages and schools, install electricity generators in public roads and facilities, and renovate village access roads. On the education front, WBN contributed to projects to train teachers, provide school supplies and equipment, construct school dormitories, and provide scholarships. The project team has also contributed to activities to improve healthcare and local business.

[59] WBN, 2013.
[60] WBN, 2013.
[61] MIGA, 2010.
[62] WBN, 2013.

Suggested Resolution

The NGOs and concerned citizens complaints that were formalized by the CAO Ombudsman team (outlined in the Environmental and Social Impacts sections of this report) allege that the adherence to environmental and social commitments are insufficient. In order to alleviate the remaining concerns, the CAO Ombudsman team attempted to work with the complainants to explore options for resolving the complaint issues.[63] However, the complainants informed the CAO that they would not participate in or support a dispute resolution or dialogue process. The CAO Ombudsman recommended the following options to achieve the best possible social and environmental outcomes from the WBN project:

- In continuing to develop the Environmental, Social and Health Impact Assessment underway, WBN may consider further enhancing its ongoing consultations with local community members and discuss the issues raised.
- WBN may want to explore how they can build on and improve their existing community relations and communications activities to engage more directly with local community members.
- Parties could hire a conflict resolution/facilitation professional (or organization) who would be accepted as credible and neutral by all parties to assist with existing community engagement and development activities and systems.
- Parties should discuss and agree on a constructive approach for preventing and dealing with problems and conflicts when they arise in the future, recognizing that some tensions and differences will be ongoing and unforeseen problems will arise.

Background on Climate Change and Mining Projects[64]

The International Council on Mining & Metals (ICCM) commissioned a report to explore the impacts of global climate change on the mining and metals industry. The report focused on the impacts of higher temperatures, shifts in precipitation patterns, sea level rise, and extreme events. The report presented a framework to investigate the impact of these climate shifts on industry inputs (e.g. water, energy, and people), the supply chains, markets, exploration, construction, operations, closure and post-closure, and business implications. The report applies this framework to three focus areas: arid or water stressed areas, tropical regions (e.g. Indonesia), and coastal areas or locations (e.g. Weda Bay).

The ICCM report presents a framework for evaluating climate change risks to the mining and minerals sector (see Figure 9). The subsequent narrative provides detailed descriptions of how increased temperatures, shifts in precipitation patterns, sea level rise, and extreme events could affect the impact areas. Since the purpose of this document is to focus on the potential climate change impacts for the PT Weda Bay Nickel Mine, the discussion below is more detailed for the relevant impact areas of inputs and operations.

[63] IFC, 2011.
[64] ICCM, 2013.

Figure 9: Mining and minerals sector climate change risks evaluation framework

Impact areas	Impact evaluation	Business implications
Inputs	**Description** What is the impact?	**Financial** Higher operating expenditure or unplanned capital expenditure
Supply chains	**Timeframe** When will the impact occur? When is action necessary?	**Reputational** Increased risk of litigation, regulatory non-compliance, inability to operate
Markets	**Stakeholders** Who is impacted?	
Exploration	**Primary/secondary** Does the impact directly affect activities or does it trigger other impacts?	
Construction	**Likelihood** How certain is the impact? How much more often is it likely to occur?	
Operation		
Closure		
Post-closure		

Inputs There are three key inputs that are crucial to mining and will likely be affected by climate change impacts: water, energy, and people. Depending on the type of mine and the location, increased temperatures, changes in precipitation patterns, sea level rise, and extreme events could each impact these critical inputs.

- *Water* is essential to mine operations. It is used in cooling, crushing, grinding, milling ore, slurry transport, and tailings storage. Shifts in precipitation patterns may impact the seasonal availability and the quality of water. Water supply is a particular concern in areas that are prone to drought, areas that will experience decreased precipitation in the future, and coastal areas with potential salt-water intrusion risks. Water is also critical to the generation of hydroelectricity, which is frequently used in mining operations.
- *Energy* is required in mining and metals operations to break, move, and process tons of ore. Hydroelectricity power production is susceptible to shifts in the water supply and river flows. Conventional power facilities can also be vulnerable if temperature increases alter the water resources needed for cooling water or turbines. Electricity transmission pathways are also vulnerable to disruption by flooding or extreme weather.
- *People* are needed to construct and operate the mines. The health and safety of employees and the broader community may be impacted by heat exposure, cardiovascular and respiratory diseases, and microbial or vector-borne pathways. Higher temperatures, changes in precipitation, and extreme events are also likely to impact agricultural production. Climate stresses on the supply of clean water may result from decreased precipitation, sea level rise that may cause saltwater intrusion, and extreme events.

Supply Chains are necessary to transport materials to the market. Local climate change may disrupt immediate transportation facilities such as roads, rail, and ports. Since mining and minerals are traded on a global market, impacts on transportation facilities can go beyond the local climatic conditions. There may be complications with supply chains and logistics – both bringing materials to the mines and distributing the products of the mines.

Markets may shift as the economic interactions change. The value of metals and minerals will fluctuate as demands for carbon intensive materials and processes shift.

Exploration and competition may increase with increased access to new ore reserves in the Arctic.

Construction of the mine and infrastructure will occur over a fixed period of time. Although the inputs to the construction (including water, energy, and employees mentioned above) may be affected by climate change and the long-term viability of infrastructure may be impacted, climate change will have limited impact on construction because of its relatively short duration. However, engineering standards and building codes often reflect past or experienced climate; this may likely result in the construction of facilities that are not designed to withstand future climatic conditions. Integrating climate projections into the design and construction of infrastructure would make the structures more prepared for future climate.

Operation of the mining facility is a long-term, heavy infrastructure investment. Flooding, subsidence, erosion and storms could have major impacts on the fixed assets and infrastructure upon which mining operations depend. Impacts may include compromising structural integrity of infrastructure, operational disruptions during storms, and decrease operational efficiency. Additionally, changes in temperature, hydrology, and soil moisture may impact the viability of waste containment structures. Increased precipitation and temperatures may also accelerate weathering of waste rock, which can cause early onset and increased volume of acid mine drainage.

Closure and Post-Closure cost estimates are required for mine operators. A changing climate could result in environmental impacts that exceed initial estimates.

Local Conditions

CURRENT LOCAL CLIMATE

Indonesia is comprised of five large islands and approximately 13,667 small islands, of which only about 7% are permanently inhabited. The country covers 790 million ha, with a total coastline of 81,000 km. Halmahera is located in the northern Maluku islands. Indonesia's climate is dominated by monsoons and the islands lie across the range of the Inter-tropical Convergence Zone. Northeast and southeast trade winds penetrate the doldrums and the zone is characterized by overcast skies, strong squalls, and severe thunderstorms.[65]

Halmahera is located in the region characterized by localized rainfall pattern that results in a wet season from April through September and a drier season from October through March. Indonesia has two other rainfall types that characterize other parts of the archipelago – the monsoon rainfall and the equatorial rainfall.

ENSO (El Niño Southern Oscillation)[66]

Rainfall variability is strongly affected by ENSO (El Niño Southern Oscillation). El Niño years are characterized by a late end to and even less rain during the dry season. Conversely, the La Niña years have relatively brief dry seasons with more rain. In Indonesia the wet season can vary from 100-110 days[67] to 280-300 days. Historically, extreme climate events in Indonesia are typically associated with ENSO. El Niño events have become more frequent over recent years, as global temperature anomalies increase. Between 2003 and 2005 approximately 1,429 disasters occurred in Indonesia. About 53% were hydro-meteorological disasters with 34% floods and 16% landslides.

CLIMATE CHANGE PROJECTIONS

Climate change impacts on precipitation

The 2010 Indonesia Second National Communication under the UNFCCC indicates that climate change is anticipated to shift precipitation patterns in Indonesia. Table 1 extracts the projected climate shifts for Halmahera Island as projected in the maps in Figure 10. The general trend under the A2 and B1 scenarios are

[65] Ministry of Environment, Republic of Indonesia, 2010.
[66] Ministry of Environment, Republic of Indonesia, 2010.
[67] UNFCCC 2nd Communication states that the wet season can vary from 10-110 days to 280-300 days; based on the magnitude of variation between rainfall, it is logically assumed that the report neglected a zero and that the correct statement is "100-110 days".

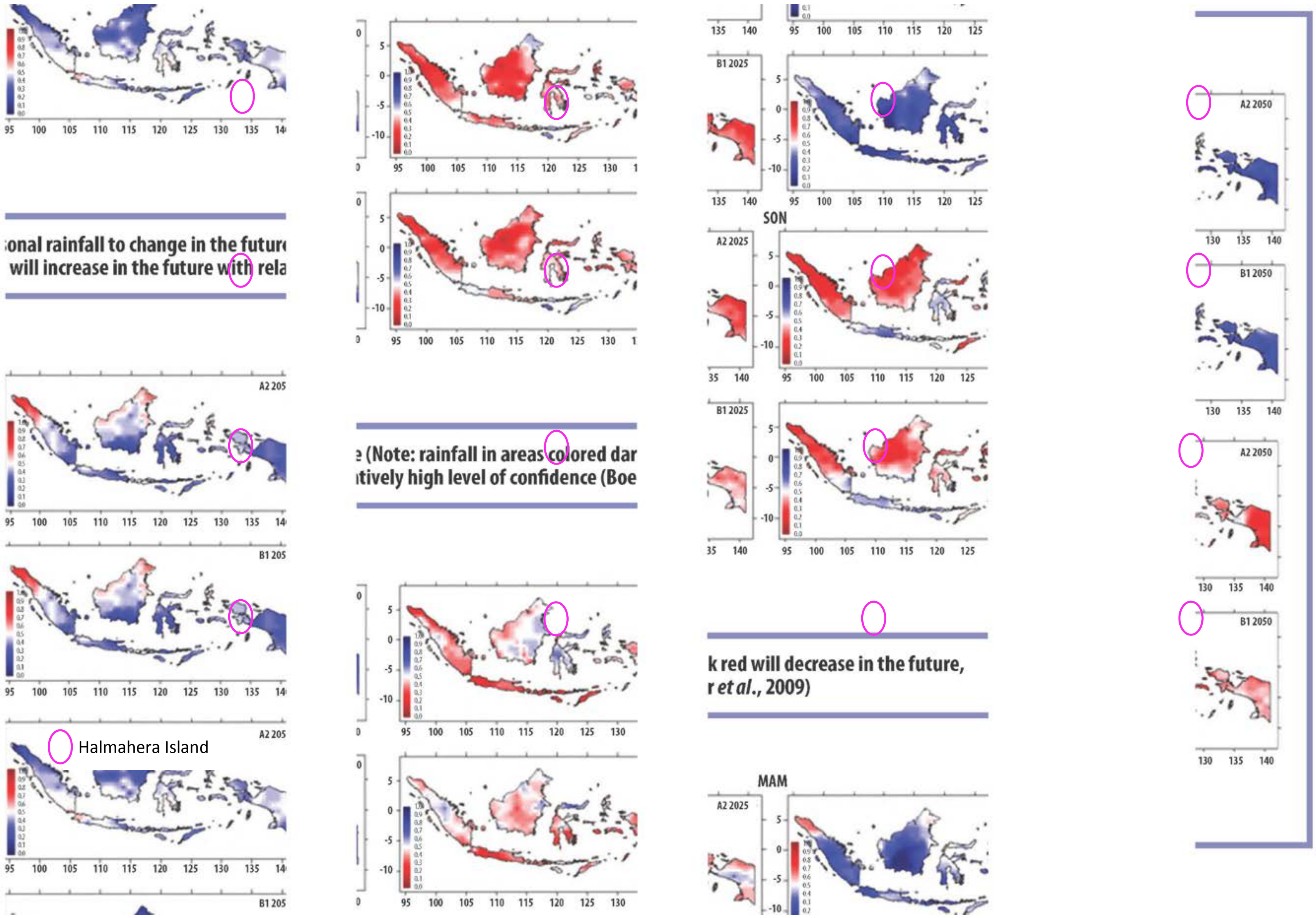
similar showing decreases in precipitation by 2025 and increases during all quarters, except for September – November, by 2050.[68]

Table 1: Summary of projected precipitation changes for Halmahera Island, Indonesia. (Adapted from Ministry of Environment, Republic of Indonesia, 2010).

Months	Dec/Jan/Feb	Mar/Apr/May	June/July/Aug	Sept/Oct/Nov
Season	Dry Season	Wet Season	Wet Season	Dry Season starts in October
2025	No significant shift	**Slight decrease**	No significant shift	**Decrease**
2050	**Slight increase**	**Increase**	**Increase**	**Decrease**

[68] Ministry of Environment, Republic of Indonesia, 2010.

Figure 10: Projected Seasonal Shifts in Rainfall through 2050 (Ministry of Environment, Republic of Indonesia, 2010).



Climate change impacts on temperature

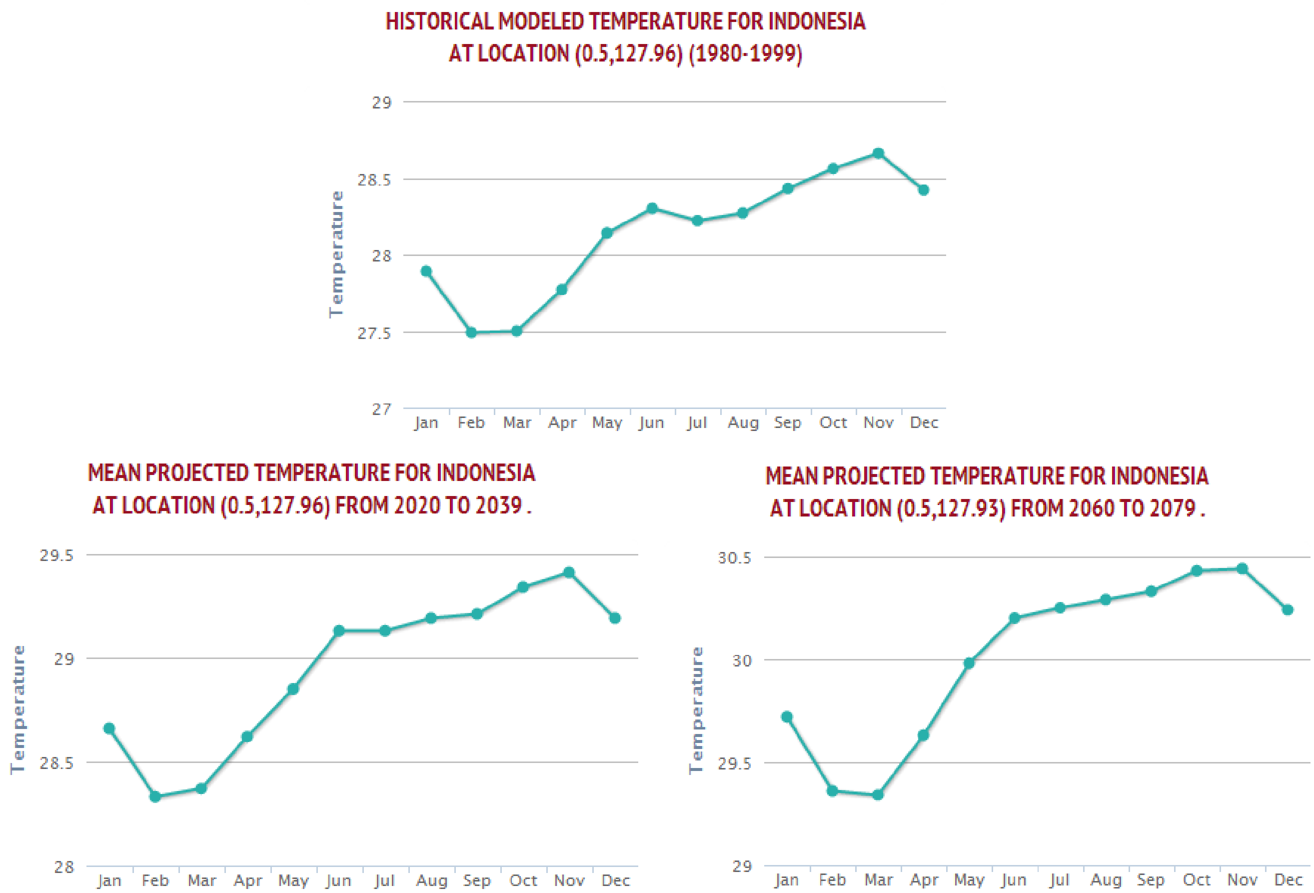
The World Bank Climate Change Knowledge Portal provides downscaled projections for monthly average temperatures in Indonesia. Due to the vast size and variety of climate in Indonesia, the data below is selective and location specific. Under both the A2 and B1 climate scenarios, average monthly temperatures in Weda Bay are projected to increase, nearly 1°C by 2039 and approximately 2°C by 2079. The largest shift in monthly temperatures is projected for June through October, during the wet season.[69] Figure 11 shows monthly temperature changes for Weda Bay and Table 2 provides a selective snapshot highlighting the shifts during the warmest month (November), the coldest month (historically February, shifts to March by 2060-2079), and the months with the most significant increases in average monthly temperature (July and August).

Table 2: Summary of average monthly temperature changes for Weda Bay, Indonesia. Temperatures shown in degrees Celsius. (Adapted from World Bank, 2013).

			Historical Avg. Monthly Temp 1980-1999	**Avg. Monthly Temperature 2020-2039**	**Change from 1980-1999 to 2020-2039**	**Avg. Monthly Temperature 2060-2079**	**Change from 1980-1999 to 2060-2079**
Coldest Month (February/March)			27.49	28.33	+0.84	29.34	+1.85
July			28.22	29.13	+0.91	30.25	+2.03
August	28.27	29.19	+0.92	30.29		+2.02	
Warmest Month (November)	28.66	29.41	+0.75	30.44		+1.78	

[69] World Bank, 2013.

Figure 11: Historical and Projected Average Monthly Temperature for Weda Bay, Indonesia. Temperatures shown in degrees Celsius (World Bank, 2013).



Sea level rise

Indonesia has 81,000 km of coastline. Sea level rise will have variable consequences across the country's islands. Precise local estimates are not available. Sea level rise may impact the Halmahera coast and nearby communities and infrastructure.

Potential Impacts of Climate Change on Project

PROJECT INFRASTRUCTURE AND OPERATIONS

The current climate change projections show that Halmahera Island and Weda Bay will likely experience an increase in temperature and a shift in precipitation patterns with increases in all seasons with the exception of the end of the wet season/beginning of the dry season. Additionally, an increase in the intensity of the ENSO cycle will result in shorter dry seasons during La Niña years and less rain during El Niño years. Changes in water resources, flooding, temperatures and sea level rise may impact project assets and operations. Shifts or increases in microbial or vector-borne diseases may also impact the health of the labor force.

Flooding

During extreme flooding events, project infrastructure may be damaged. Buildings and access roads may be damaged by extreme rainfall. Floods may disrupt mining operations temporarily if roads are impassable or damaged. Temporary disruption will cause financial losses by reducing or postponing production days. Floods that cause structural damage may cause extended delays and costs associated with repairing or rebuilding damaged assets. Flooding that impacts the residue storage facility, sediment ponds, and topsoil and overburden stockpiles could result increase the environmental impacts of the site. The hilly topography of Halmahera Island is also susceptible to landslides during extended periods of rainfall or extreme events.

Increased Temperature

Increased temperatures may have an impact on infrastructure efficiency and degradation. Warmer air and water temperatures may increase the temperature of machinery and require production to be reduced or slowed. Additionally, increased temperatures will likely have an impact on employee health and productivity. Higher temperatures and more frequent incidents of extreme heat may lead to heat exhaustion or stress, the range of microbial and vector-borne diseases may shift.

Changes in ENSO

Shifts in ENSO (El Niño Southern Oscillation) will alter the precipitation patterns in Indonesia. Some studies have shown that global temperature anomalies associated with each El Niño has continued to increase, suggesting that El Niño events have become more frequent. Thus, increasingly high temperatures are exacerbating extreme regional weather patterns, including El Niño.[70] More extreme weather patterns increase the risk for disruption and damage of WBN assets. Roads, ports, the airstrip, storage facilities, processing plants, and buildings could all be affected by stronger winds, severe rainfall, and storms.

Sea Level Rise

Sea level rise will have the most significant impact on coastal resources. Aside from the airport, dedicated port, and plant site, most project assets are located on sites that are not directly on the coast. Without specific sea level rise projections for Weda Bay and elevation maps, it is not possible to project the precise impacts on project infrastructure. However, as shown in the Project Layout (Figure 5), Gamaf and Leilef villages are coastal, as is the Trans Halmahera Highway. While these are not project assets, sea level rise impacts on the villages and the highway may have a secondary impact on the project, affecting the supply chain to and from the mining operations. The port, plant site, and airport may experience an increase in coastal flooding. Additionally, if water resources are located close to the coast, salt water intrusion into the water supply may be a challenge.

Decreased Precipitation

Although precipitation is projected to increase during all seasons except for September – November, shifts in ENSO, seasonal shortages, or slight decreases between March – May until 2025 could reduce the availability of water. If the project relies on hydroelectric power, a reduction in streamflow or the water supply could impact the availability of power. Additionally, seasonal shortages may reduce the availability of water for mine operations and employee accommodations.

Adaptation Options

The current climate change projections suggest that shifts in ENSO will have the most significant impact on WBN. Since the mine is a long-term investment with an anticipated lifespan of more than thirty years, it is important to incorporate climate change into the design of mining infrastructure. Although local climate change projections for the Indonesia have been developed; there is considerable uncertainty in precipitation changes and how increased temperatures will impact ENSO in Weda Bay, making it difficult to prescribe specific adaptation options. Nevertheless, there is a need for the project developer to consider the likely range of changes in climate based on the existing studies. This will help improve confidence in planning and reduce costs over the long term. Additionally, it is important to monitor the local conditions and evaluate new information to

[70] Ministry of Environment, Republic of Indonesia, 2010.

improve understanding of the future conditions and determine the appropriate adaptation actions (See the Monitoring and Evaluation section for more information).

Increases in precipitation, temperatures, extreme events, and sea leave rise should all be incorporated into site design and operational procedures for the mining facilities. The average temperatures in Indonesia are already high. Facility construction, operations expectations, and employee output projections should take into account the impact of elevated temperatures on productivity and function. Additionally, as the intensity of precipitation events increases, subsequent flooding and landslides may cause damage to facilities and access roads. Flood and landslide risk should be considered in site selection and design.

Roads

Materials used for road construction should be able to withstand increased daily and average temperatures. Additionally, site selection for roads and reinforcement structures should be used to minimize closure and damage from flooding and landslides. Redundancy may be necessary for certain areas of road that are highly susceptible to erosion and flooding, particularly along the coast. Slope stabilization should be incorporated into the design of roads to ensure improved protection from landslides. For the future development of roads, siting and design decisions should incorporate considerations for the increase in heavy rainfall, particularly with regards to landslide risk. If the Trans Halmahera Highway is used for operations or transporting employees to and from the accommodation facilities, alternate routes may be necessary if the road is at risk of coastal flooding.

Mining Pits

Landslides are currently a concern for communities and developments across Indonesia. The steep slopes on Halmahera increase the potential for landslides that may impact the mining operations. Slope stabilization should be incorporated into the construction and excavation practices for the mining pits.

Employee Accommodation Facilities

Accommodation facilities should be designed for future climate. Buildings should have adequate cooling devices and a sufficient energy supply should be secured. Alternative building designs that utilize passive cooling may reduce the need for additional energy under hotter conditions. Similarly, relying on a renewable energy source, such as solar energy as opposed to hydroelectric power may increase resiliency in the case of low precipitation and/or extreme heat. Sea level rise and the impact of extreme weather on the buildings should be incorporated into the site and building design.

Water Resources

The availability of water resources may change in the future. Decreased seasonal precipitation and more extreme El Niño events may limit the water supply. It is important for the mine to integrate future projections of both periodic decreases and increases in precipitation into planning for mining operations and maintenance of support facilities.

Dedicated Port, Barge Loading Facility, and Airport

The design and siting of the port, barge loading facility, and airport should incorporate future sea level rise. Considerations for coastal flooding should be made to ensure maximum use of the port, loading facility, and airport.

Residue Storage Facility

The residue storage facility is strategically designed to reduce contamination of groundwater and the Jira River. The design and engineering of this facility should incorporate the potential for increased precipitation and shifts in extreme events. Unprecedented flooding events or landslides could cause contamination to leak from the storage facility. Since this facility is located in the upper Jira river watershed, the impacts of contamination could spread beyond the isolated location of the facility.

Monitoring and Evaluation

Monitoring and evaluation will be critical to establish an ongoing understanding of how climate will impact the PT Weda Bay Nickel on Halmahera Island, Indonesia. A baseline should have been established before the construction of the project, and comprehensive monitoring and evaluation activities should occur on regular intervals, including during the construction and operation phase. Monitoring and evaluation plans should seek to monitor three elements of the project: (1) the overall project success, (2) environmental and social impacts, and (3) climate variables.

The project should establish a results-based M&E framework with clear stated benefits for the construction and operations of project assets. A critical component of the framework is the results chain which details the progression from allocated resources (inputs) to constructed assets (outputs), to results from the operations of those assets (outcomes) to the ultimate benefits (impact). Monitoring and evaluation activities occur at all levels of the chain to ensure that the project has the required resources; important construction milestones are met; operational targets are achieved and that benefits such as economic growth occur.

The objectives of the Environmental Monitoring Plan have the stated objectives of: (1) "Monitoring environmental components impacted by the activities of the Nickel and Cobalt mining and processing project according to the ANDAL[71] study" and (2) "Demonstrating that Environmental management is successful in mitigating negative impacts and maximizing positive impacts."[72] The Environmental Monitoring Plan specifies the extensive monitoring plan. The following environmental component or activity will be monitored at the project stages listed in Figure 12:

[71] ANDAL is the first section of the AMDAL.
[72] ERM, 2009b.

Figure 12: Summary of the project *Environmental Monitoring Plan (RPL)* (ERM, 2009c).

Environmental Component/Activity	Pre-Construction Stage	Construction Stage	Operation Stage of Ore Mining	Operation Stage of Ore Processing	Operation Stage of Lime Quarry and Processing	Operations Stage of Supporting Facilities	Operations Stage of Other Infrastructure	Community Development	Other Monitoring
Air Quality		√	√	√	√	√	√		
Noise		√	√		√	√	√		
Vibration					√				
Morphology and Physiographic			√		√				
Hydrology		√	√		√	√			
Hyrdogeology					√				√
Soils	√	√	√		√				
Meteorology and Microclimate									√
Terrestrial Flora and Fauna	√	√	√		√				
Flora and Fauna Biodiversity									√
Flora and Fauna in Natural Succession Area									√
Freshwater Aquatic Biota	√	√	√	√	√				
Marine Biota		√		√			√		
Oceanography							√		
Sea Water Quality		√		√			√		
Surface Water Quality	√	√	√	√	√	√			√
Groundwater Quality				√		√			√
Community Shallow Ground Water Wells Quality									√
Reclamation Progress									√
Job Opportunities	√	√	√						
Business Opportunities		√	√		√	√		√	
Community Income	√	√	√		√	√			
Land Ownership	√								
Livelihood Pattern	√	√	√						
Migration		√	√						
Assimilation and Acculturation		√	√						
Alteration of Social Values and Norms		√	√						
Community Unrest	√	√	√						
Public Health		√	√						
Provision of Public Health Services								√	
Provision of Educational Facilities and Services								√	
Quality of Indigenous People Habitat			√						
Fishery and Marine Culture								√	
Farming and Agriculture Improvement Initiatives								√	

To improve upon the existing monitoring program, WBN should incorporate metrics that measure climatic conditions and the impact of those conditions on the project resources and assets. Specifically, the project should establish protocol for measuring and reporting local precipitation, temperature, length of the wet and dry seasons, sea level rise, and extreme events. This data should be assessed with regards to the infrastructure, operations, and shifts in local agricultural production (as part of the farming and agricultural improvement incentives). Additionally, extreme weather, extended heat events, and the occurrence of microbial and vector-borne diseases should be monitored.

The ICCM report, "Adapting to a changing climate: implications for the mining and metals industry" suggest that monitoring may include:[73]

- Monitoring long term environmental indicators such as water availability, ecosystem integrity, location and health of flora and fauna.
- Monitoring regional stressors such as the frequency and magnitude of extreme events.
- Periodic review of infrastructure and equipment design to ensure that original climatic assumptions are still valid.
- Tracking implementation and effectiveness of adaptation actions.
- Assessing impacts of both historical extreme events and incremental changes on system components and maintenance.

Establishing a monitoring protocol based on the likely impacts of climate change in the region will help inform future decision-making for the company and investors. Uncertainties in the magnitude and timing of climate change impacts make it difficult to plan for climate change. An effective monitoring and evaluation program will help alleviate these concerns and aid decision making by providing data that can help inform decisions about adaptation.

[73] ICCM, 2013.

Resources

AECOM. 2011. The Land Preparation for Construction (LPC) Project Environmental Social and Health Impact Assessment. Available at: http://www.miga.org/documents/ESRS_Health_Impact_Assessment_LPC_weda.pdf

Environmental Resources Management (ERM). 2009a. ANDAL Chapter 1. Available at: http://www.miga.org/documents/WedaBay_EIA_ANDAL.pdf

Environmental Resources Management (ERM). 2009b. Environmental Management Plan. Available at: http://www.miga.org/documents/WedaBay_EnvironmentalManagementPlan.pdf.

Environmental Resources Management (ERM). 2009c. Environmental Monitoring Plan. Available at: http://www.miga.org/documents/WedaBay_EnvironmentalMonitoringPlan.pdf

Environmental Resources Management (ERM). 2010. Eramet-PT Weda Bay Nickel Exploration and Development ESIA. Available at: http://www.miga.org/documents/WedaBay_ExplorationandDevelopment_ESIA.pdf

International Council on Mining & Metals (ICCM). 2013. Adapting to a changing climate: implications for the mining and metals industry. Available at: https://www.icmm.com/page/92086/adapting-to-a-changing-climate-implications-for-the-mining-and-metals-industry

International Finance Corporation (IFC) / Multilateral Investment Guarantee Agency (MIGA). 2011. Ombudsman Assessment Report – Complaint Regarding the MIGA PT Weda Bay Nickel Project (#8113) Halmahera Island, North Maluku, Indonesia. Available at: http://www.cao-ombudsman.org/cases/document-links/documents/WBN_Assessment_FINAL_with_appendices_ENG.pdf

Ministry of Environment, Republic of Indonesia. 2010. Indonesia Second National Communication under the United National Framework Convention on Climate Change. Available at: http://www.undp.org/content/lao_pdr/en/home/operations/projects/environment_and_energy/second_communication_climate_change.html

Multilateral Investment Guarantee Agency (MIGA). 2010. Environmental and Social Review – Weda Bay Nickel Mine Project Exploration and Feasibility Study. Available at: http://www.miga.org/documents/WedaBay_ESRS.pdf

Multilateral Investment Guarantee Agency (MIGA). 2013a. PT Weda Bay Nickel Indonesia Project Brief. Available at: http://www.miga.org/projects/index.cfm?pid=828

Multilateral Investment Guarantee Agency (MIGA). 2013b. Environmental and Social Review – Weda Bay Nickel Mine Project Land Preparation for Construction. Available at: http://www.miga.org/documents/ESRS_Land_Preparation_Construction_Weda.pdf

Multilateral Investment Guarantee Agency (MIGA). 2013c. Environmental and Social Safeguards. Available at: http://www.miga.org/projects/index.cfm?stid=1822

Weda Bay Nickel (WBN). 2013. Project Website. Accessed August 27, 2013. Available at: http://www.wedabaynickel.com/en/

World Bank. 2013. Climate Change Knowledge Portal. Indonesia. Accessed August 27, 2013. Available at: http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Asia&ThisCCode=IDN

Wulandari, Fitri. 2013. Eramet Unit, Indonesia Agree on Some Contract Review Points. Bloomberg News. February 4, 2013. Available at: http://www.businessweek.com/news/2013-02-04/eramet-unit-indonesia-agree-on-some-contract-review-points. Accessed September 26, 2013.